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STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1: PROPOSED STANDARDS OF PERFORMANCE FOR KRAFT PULP MILLS

ENVIRONMENTAL PROTECTION AGENCY,
RESEARCH TRIANGLE PARK, NORTH CAROLINA

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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16. ABSTRACT

Standards of performance for the control of emissions of total reduced sulfur (TRS) and particulate matter from new and modified kraft pulp mills are being proposed under the authority of section 111 of the Clean Air Act. TRS emissions from kraft pulp mills are extremely odorous, and there are numerous instances of poorly controlled mills creating public odor problems. The proposed standards would prevent odor problems from most newly constructed kraft pulp mills, except in the immediate vicinity of the mills on occasions when meteorological conditions produce downwash of stack plumes. Particulate matter emissions from new mills would be reduced by more than 99 percent below the levels that would result from no control and more than 50 percent below the average levels that are being achieved by existing facilities controlled to the average State standards. Emissions of TRS would be reduced by more than 95 percent below the uncontrolled levels and more than 80 percent below the average levels for existing sources. An analysis of the environmental and economic effects associated with the proposed standards is included in this document.

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Emission Standards and Engineering Division

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INTRODUCTION

Standards of performance under section 111 of the Clean Air Act are proposed following a detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This document summarizes the information obtained from such a study of the kraft pulping industry. Its purpose is to explain in detail the background and basis of the proposed standards and to facilitate analysis of the proposed standards by interested persons, including those who may not be familiar with the many technical aspects of the industry. To obtain additional copies of this document or the Federal Register notice of proposed standards, write to Public Information Center (PM-215), Environmental Protection Agency, Washington, D. C. 20460 (specify Standard Support and Environmental Impact Statement: **Standards of Performance for Kraft Pulp Mills**, Volume I).

AUTHORITY FOR THE STANDARDS

Standards of performance for new stationary sources are developed under section 111 of the Clean Air Act (42 USC 1857c-6), as amended in 1970. Section 111 requires the establishment of standards of performance for new stationary sources of air pollution which ". . .may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare." The Act requires that standards of performance for such sources reflect ". . .the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

Section 111 prescribes three steps to follow in establishing standards of performance.

1. The Administrator must identify those categories of stationary sources for which standards of performance will ultimately be promulgated by listing them in the Federal Register.
2. The regulations applicable to a category so listed must be proposed by publication in the Federal Register within 120 days of its listing. This proposal provides interested persons an opportunity for comment.
3. Within 90 days after the proposal, the Administrator must promulgate standards with any alterations he deems appropriate.

Standards of performance, by themselves, do not guarantee protection of health or welfare; that is, they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect best demonstrated technology (taking into account costs) for the affected sources. The overriding purpose of the collective body of standards is to maintain existing air quality and to prevent new pollution problems from developing.

Previous legal challenges to standards of performance have resulted in several court decisions[1,2] of importance in developing future standards. In those cases, the principal issues were whether EPA: (1) made reasoned decisions and fully explained the basis of the standards, (2) made available to interested parties the information on which the standards were based, and (3) adequately considered significant comments from interested parties.

Among other things, the court decisions established: (1) that preparation of environmental impact statements is not necessary for standards developed under section 111 of the Clean Air Act because, under that section, EPA must consider any counter-productive environmental effects of a standard in determining what system of control is "best;" (2) in considering costs it is not necessary to provide a cost-benefit analysis; (3) EPA is not required to justify standards that require different levels of control in different industries unless such different standards may be unfairly discriminatory; and (4) it is sufficient for EPA to show that a standard can be achieved rather than that it has been achieved by existing sources.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. On the contrary, section 116 of the Act (42 USC 1857-D-1) makes clear that States and other political subdivisions may enact more restrictive standards. Furthermore, for heavily polluted areas, more stringent standards may be required under section 110 of the Act (42 USC 1857c-5) in order to attain or maintain national ambient air quality standards prescribed under section 109 (42 USC 1857c-4). Finally, section 116 makes clear that a State may not adopt or enforce less stringent new source standards than those adopted by EPA under section 111.

Although standards of performance are normally structured in terms of numerical emission limits where feasible,[1] alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions (high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

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[1] "'Standards of performance,' . . . refers to the degree of emission control which can be achieved through process changes, operation changes, direct emission control, or other methods. The Secretary [Administrator] should not make a technical judgment as to how the standard should be implemented. He should determine the achievable limits and let the owner or operator determine the most economical technique to apply." Senate Report 91-1196.

SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 directs the Administrator to publish and from time to time revise a list of categories of sources for which standards of performance are to be proposed. A category is to be selected ". . . if [the Administrator] determines it may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare."

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. In brief, the approach that has evolved is as follows. Specific areas of interest are identified by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are primarily emitted by stationary sources. Source categories which emit these pollutants are then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might result from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of performance for the source category. An estimate is then made of the time required to develop a standard. In some cases, it may not be feasible to develop a standard immediately for a source category with a high priority. This might occur because a program of research and development is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. The schedule of activities must also consider differences in the time required to complete the necessary investigation for different source categories. Substantially more time may be necessary, for example, if a number of pollutants must be investigated in a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling.

Selection of the source category leads to another major decision: determination of the types of facilities within the source category to which the standard will apply. A source category often has several facilities that cause air pollution. Emissions from some of these facilities may be insignificant or very expensive to control. An investigation of economics may show that, within the costs that an owner could reasonably afford, air pollution control is better served by applying standards to the more severe pollution problems. For this reason (or perhaps because there may be no adequately demonstrated system for controlling emissions from certain facilities), standards often do not apply to all sources within a category. For similar reasons, the standards may not apply to all air pollutants emitted by such sources. Consequently, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Congress mandated that sources regulated under section 111 of the Clean Air Act be required to utilize the best system of air pollution control (considering costs) that has been adequately demonstrated at the time of their design and construction. In so doing, Congress sought to:

1. Maintain existing high-quality air,
2. Prevent new air pollution problems, and
3. Ensure uniform national standards for new facilities.

Standards of performance, therefore, must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost of such control; (3) be applicable to existing sources that are modified as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best system of emission reduction which "has been adequately demonstrated (considering cost)." The legislative history of section 111 and the court decisions referred to earlier make clear that the Administrator's judgment of what is adequately demonstrated is not limited to systems that are in actual routine use. Consequently, the search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. In most cases, determination of the "degree of emission limitation achievable" is based on results of tests of emissions from existing sources. This has required worldwide investigation and measurement of emissions from control systems. Other countries with heavily populated, industrialized areas have sometimes developed more effective systems of control than those used in the United States.

Since the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which standards are developed may be somewhat limited. Test data on existing well-controlled sources are obvious starting points in developing emission limits for new sources. However, since the control of existing sources generally represents retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered and judgment is necessarily involved in setting proposed standards.

Since passage of the Clean Air Amendments of 1970, a process for the development of a standard has evolved. In general, it follows the guidelines below.

1. Emissions from existing well-controlled sources are measured.
2. Data on emissions from such sources are assessed with consideration of such factors as: (a) the representativeness of the source tested (feedstock, operation, size, age, etc.); (b) the age and maintenance of the control equipment tested (and possible degradation in the efficiency of control of similar new equipment even with good maintenance procedures); (c) the design uncertainties for the type of control equipment being considered; and (d) the degree of uncertainty that new sources will be able to achieve similar levels of control.
3. During development of the standards, information from pilot and prototype installations, guarantees by vendors of control equipment, contracted (but not yet constructed) projects, foreign technology, and published literature are considered, especially for sources where "emerging" technology appears significant.
4. Where possible, standards are developed which permit the use of more than one control technique or licensed process.

5. Where possible, standards are developed to encourage (or at least permit) the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control
6. Where possible, standards are developed to permit use of systems capable of controlling more than one pollutant (for example, a scrubber can remove both gaseous and particulate matter emissions, whereas an electrostatic precipitator is specific to particulate matter).
7. Where appropriate, standards for visible emissions are developed in conjunction with concentration/mass emission standards. The opacity standard is established at a level which will require proper operation and maintenance of the emission control system installed to meet the concentration/mass standard on a day-to-day basis, but not require the installation of a control system more efficient or expensive than that required by the concentration/mass standard. In some cases, however, it is not possible to develop concentration/mass standards, such as with fugitive sources of emissions. In these cases, only opacity standards may be developed to limit emissions.

CONSIDERATION OF COSTS

Section 111 of the Clean Air Act requires that cost be considered in developing standards of performance. This requires an assessment of the possible economic effects of implementing various levels of control technology in new plants within a given industry. The first step in this analysis requires the generation of estimates of installed capital costs and annual operating costs for various demonstrated control systems, each control system alternative having a different overall control capability. The final step in the analysis is to determine the economic impact of the various control alternatives upon a new plant in the industry.

The fundamental question to be addressed is whether or not a new plant would be constructed if a certain level of control costs would be incurred. Other issues that are analyzed are the effects of control costs upon product prices and product supplies, and producer profitability.

The economic impact upon an industry of a proposed standard is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing State control regulations. This incremental approach is taken since a new plant would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that exists between a standard of performance and the typical State standard.

The costs for control of air pollutants are not the only costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry as this factor also influences the ability of new plants to generate the capital required for installation of the additional control equipment needed to meet the standards of performance.

CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(c) of the National Environmental Policy Act (NEPA) of 1969 (PL 91-190) requires Federal agencies to prepare detailed environmental statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

As mentioned earlier, in a number of legal challenges to standards of performance for various industries, the Federal Courts of Appeals have held that environmental impact statements need not be prepared by the Agency for proposed actions under section 111 of the Clean Air Act. Essentially, the Federal Courts of Appeals have determined that "...the best system of emission reduction," "...require(s) the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry..." On this basis, therefore, the Courts "...established a narrow exemption from NEPA for EPA determinations under section 111."[1,2]

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969."

The Agency has concluded, however, that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, while not legally required to do so by section 102(2)(c) of NEPA, environmental impact statements will be prepared for various regulatory actions, including standards of performance developed under section 111 of the Clean Air Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, therefore, a separate section is included in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are identified and discussed.

IMPACT ON EXISTING SOURCES

Standards of performance may affect an existing source in either of two ways. Section 111 of the Act defines a new source as "any stationary source, the construction or modification of which is commenced after the regulations are proposed." Consequently, if an existing source is modified after proposal of the standards, with a subsequent increase in air pollution, it is subject to standards of performance. [Amendments to the general provisions of Subpart A of 40 CFR Part 60 to clarify the meaning of the term modification were promulgated in the FEDERAL REGISTER on December 16, 1975 (40 FR 58416).]

Secondly, promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under section 111(d) of the Act if the standard for new sources limits emissions of a pollutant for which air quality criteria have not been issued under section 108 or which has not been listed as a hazardous pollutant under section 112. If a State does not act, EPA must establish such standards. [General provisions outlining procedures for control of existing sources under section 111(d) have been promulgated on November 17, 1975 as Subpart B of 40 CFR Part 60 (40 FR 53340).]

REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator may revise such standards from time to time. Although standards proposed and promulgated by EPA under section 111 are designed to require installation of the ". . . best system of emission reduction . . . (taking into account the cost). . ." the standards will be reviewed periodically. Revisions will be proposed and promulgated as necessary to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after proposal of the revised standards.

STANDARDS OF PERFORMANCE FOR TOTAL REDUCED SULFUR COMPOUNDS

The proposed standards include limitations on emissions of total reduced sulfur (TRS) compounds. Since air quality criteria have not been issued for TRS compounds and TRS compounds have not been listed as hazardous air pollutants, the promulgation of TRS standards for kraft pulp mills will require States to establish standards of performance for TRS from existing kraft pulp mills under section 111(d) of the Act.

Hydrogen sulfide, methyl mercaptans, dimethyl sulfide, and dimethyl disulfide, taken as a group, are called TRS. The most noticeable characteristic of TRS is its highly odorous nature. Public opinion surveys often identify malodors as the air pollutant that is most apparent and of greatest personal concern to the individual.[3] A recent national task group evaluating air pollution research goals indicated that odors are of considerable concern to the average person.[3] This group also concluded that odors should be considered undesirable air pollutants, whether or not they are linked to long-term health effects, simply because they constitute an annoyance to people.

Numerous cases of individuals obtaining legal redress because of damages suffered from the presence of odors have occurred.[4] The effects which resulted in compensations for damages include loss of sleep, loss of appetite, nausea, vomiting, and curtailment of the use or enjoyment of property.

The Administrator's decision to control TRS emissions under federal standards was based on the following:

1. There are no national ambient air quality standards for TRS to provide protection against the effects of TRS.
2. Although many states have adopted TRS control regulations, major sources of TRS emissions exist in several states with no TRS regulations.
3. A uniform national standard of performance for new sources would discourage movement of major TRS emitters to states with no TRS regulations.
4. Kraft pulp mills, one of the major sources of TRS emissions, are commonly located near major waterways that comprise borders between states. The potential for interstate conflict concerning control of emissions from such mills has prompted Federal investigations in the past.

The Administrator concluded that TRS should be regulated under section 111 of the Act for the following reasons:

1. In contrast with the problems presented by the six pollutants for which national ambient air quality standards have been promulgated, the TRS problem is highly localized in the vicinity of major point sources and is not complicated by the presence of numerous area sources.

Promulgating a national ambient air quality standard for TRS under section 109 would require states to submit implementation plans to attain and maintain such standards. Because of the complex problems involved in relating emissions to ambient levels, most plans would be based on the application of best demonstrated control technology to a few major sources of TRS. The same result can be accomplished more directly and efficiently through the promulgation of standards of performance.

2. Adopting national standards of performance would be more compatible with existing state regulations than adopting ambient air quality standards. Most state regulations are expressed in terms of source standards rather than ambient air standards.

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1. SUMMARY

1.1 PROPOSED STANDARDS

Standards of performance for new and modified kraft pulp mills are being proposed under the authority of section 111 of the Clean Air Act. Emissions from these sources that will be controlled are particulate matter and total reduced sulfur (TRS). Preceding the act of proposal has been the Administrator's determination that emissions from kraft pulp mills contribute to the endangerment of public health or welfare. In accordance with section 117 of the Act, proposal of the standards was preceded by consultation with appropriate advisory committees, independent experts, industry representatives, and Federal departments and agencies.

The proposed standards limit emissions of particulate matter from three affected facilities: the recovery furnace, the smelt dissolving tank, and the lime kiln. These three facilities account for virtually all of the particulate matter emissions from a kraft pulp mill. Emissions of TRS are to be limited from eight affected facilities: the digester system, the brown stock washers, the multiple effect evaporators, the black liquor oxidation system, the recovery furnace, the smelt dissolving tank, the lime kiln, and the condensate stripper system. These eight facilities account for virtually all of the odorous emissions of TRS from a kraft pulp mill. A summary of the proposed standards and monitoring requirements is presented in Table 1-1.

Table 1-1. Summary of Proposed Standards and Monitoring Requirements

	Total Reduced Sulfur			Particulate Matter					
	ppm[1]	lb/T ADP	g/kg ADP	gr/dscf	g/dscm	lb/T ADP	g/kg ADP	Opacity	Monitoring Requirements
1. Recovery Furnace System	5^2	0.15	0.075	0.044	0.1^2	2.0	1.0	35	Opacity, TRS and O_2
2. Lime Kiln	5^2	0.025	0.0125	0.067 gas 0.13 oil	0.15^2 gas 0.30^2 oil	0.55 1.07	0.0275 0.535	None None	TRS, O_2, scrubber pressure drop, fluid supply pressure
3. Smelt Tank	5	0.025	0.0125^2	0.052	0.119	0.3	0.15^2	None	Scrubber pressure drop and fluid supply pressure
4. Brown Stock Washer System	5^2	0.01	0.005	N.S.[4]	→	→	→	→	TRS,[3] firebox temperature
5. Black Liquor Oxidation System	5^2	0.01	0.005	N.S.	→	→	→	→	TRS,[3] firebox temperature
6. Condensate Stripping System	5^2	0.01	0.005	N.S.	→	→	→	→	TRS,[3] firebox temperature
7. Digester System	5^2	0.01	0.005	N.S.	→	→	→	→	TRS,[3] firebox temperature
8. Multiple-Effect Evaporator System	5^2	0.01	0.005	N.S.	→	→	→	→	TRS,[3] firebox temperature

1. By volume dry basis 4 hr average.
2. Indicates units of recommended standard.
3. In most instances separate monitoring will not be required since these sources will be oxidized in the lime kiln or recovery furnace. If they are oxidized in separate incineration or power boilers only the temperature will be monitored.
4. No Standard.

The digester system, the brown stock washer system, the black liquor oxidation system, the multiple-effect evaporator system, and the condensate stripper system are sources only of TRS emissions and constitute approximately 25 percent of the potential emissions from the average kraft pulp mill. The noncondensable gas streams from these facilities can be controlled through incineration in the recovery furnace, lime kiln, or separate incinerator. The demonstrated emission level attainable by incineration is less than 5 ppm. The proposed standards for these facilities therefore limit concentrations of TRS to 5 ppm by volume (dry basis) on a four-hour average.

The recovery furnace, the smelt dissolving tank, and the lime kiln are sources of both TRS and particulate emissions. The proposed standard limits TRS emissions from the furnace to 5 ppm by volume (dry basis) on a four-hour average and particulate emissions to 0.10 g/dscm (0.044 gr/dscf). The gas stream must be corrected to 8 volume percent oxygen when the actual concentration exceeds 8 percent. In addition, the opacity of the exhaust stream must not exceed 35 percent.

The proposed standards for the smelt dissolving tank have been developed in terms of a mass-per-unit-of-production basis. This is for the purpose of preventing circumvention by dilution due to the large amount of process air present. The proposed TRS standard limits emissions to 0.0125 g/Kg ADP (0.025 lb/T ADP); the particulate standard is proposed as 0.15 g/Kg ADP (0.30 lb/T ADP).

The proposed standards for the lime kiln limit the concentration of the TRS to 5 ppm by volume (dry basis) on a four-hour average. When burning natural gas as fuel, the proposed particulate standard is 0.15 g/dscm (0.067 gr/dscf); when burning fuel oil, the proposed standard is 0.30 g/dscm (0.13 gr/dscf). For both the TRS and particulate standards, the gas stream must be corrected to 10 volume percent when the actual oxygen concentration exceeds 10 percent.

1.2 ENVIRONMENTAL IMPACT

The beneficial and adverse environmental and economic impacts associated with the proposed standards and with the various control system alternatives that were considered are presented in this section. The impacts are discussed in detail in chapter 7, Environmental Effects, and chapter 8, Economic Impact. A matrix summarizing these impacts is included in Table 1-2. Appendix B contains a cross reference between this document and the Agency's guidelines for Environmental Impact Statements.

Alternative number 1 is the baseline system upon which the impacts associated with the other alternatives can be measured. Alternatives 2, 3, 4, and 5 are systems which are combinations of the potential best demonstrated control technologies, considering costs. These five systems are described in chapter 4, Emission Control Technology.

The impacts on air quality due to reductions in TRS and particulate emissions are beneficially large for alternatives 2, 3, 4, and 5. The impact on water supply and treatment for the same alternatives is adverse but small. This impact is due to the requirement of scrubbers on the smelt dissolving tank and the lime kiln. An adverse solid waste impact may be caused by the addition of an electrostatic precipitator to the lime kiln control system under alternatives 4 and 5. The impact, however, is considered to be small. Energy impacts will be associated with each of the alternative standards. Comparing the impacts against system number 1 shows that a small adverse energy impact is associated with alternatives 2 and 3,

Table 1-2. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF THE ALTERNATIVE STANDARDS

	Air Impact	Water Impact	Solid Waste Impact	Energy Impact	Noise and Radiation Impacts	Economic Impact	Inflationary Impact
Alternative No. 1	0	0	0	0	0	0	0
Alternative No. 2	+4	-2	0	-2	0	-1	0
Alternative No. 3	+4	-2	0	-2	0	-1	0
Alternative No. 4	+4	-2	-2	-3	0	-1	0
Alternative No. 5	+4	-2	-2	-3	0	-1	0
Delayed Standards	-3	+2	+2	+3	0	+1	0
No Standards	-3	+2	+2	+3	0	+1	0

Key: + Beneficial Impact
- Adverse Impact

0 No impact
1 Negligible Impact
2 Small Impact
3 Moderate Impact
4 Large Impact

and a moderate adverse impact is associated with alternatives 4 and 5. The additional impact assigned to systems 4 and 5 is due to the higher electrical operating requirements on an ESP and the fuel penalty of the separate incineration unit required when an ESP is used. Impacts on noise levels due to the use of any of the alternative control systems have not been quantified. It is reasonable to assume that any impacts, if they are actually present, are negligible. There are no known radiation impacts associated with any of the alternatives under consideration. The economic impacts associated with the alternatives have been judged to be negligible.

Two additional regulatory alternatives have also been considered: the impact of delayed standards and the impact of no standards. In both cases the adverse impact on air quality would be moderate to large, since the new and modified facilities that would otherwise fall under the proposed standards would be allowed to emit TRS and particulate matter at existing rates. Other impacts due to these alternatives are small positive impacts on water and solid waste, a moderate positive impact on energy, and a negligible positive economic impact.

1.3 INFLATION IMPACT

The costs associated with the proposed standards for new and modified facilities at kraft pulp mills have been judged not to be of such magnitude to require an analysis of the inflationary impact. Screening criteria have been developed by EPA to be used in the impact analysis. These criteria have been outlined in an Agency publication and include:

(1) National annualized cost of compliance.

(2) Total added production cost in relation to sales price.

(3) Net national energy consumption increase.

(4) Added demands or decreased supplies of selected materials.

Should any of the guideline values listed under these criteria be exceeded, a full inflationary impact assessment is required.

1.4 CAPACITY AND COST IMPACT

The proposed standards will impact an estimated 17 million tons of kraft pulping capacity by 1981. About one third of the capacity will be affected as a result of expansion of existing mill capacity. The remainder of the capacity will be affected by replacement of depreciated designated facilities.

The total investment costs by 1981 are projected to be approximately $104 million. The fifth year annualized costs, including depreciation and interest, are estimated at approximately $33 million. About one third of these costs will be incurred by mills expanding capacity; the remainder by mills replacing depreciated designated facilities.

2. THE KRAFT PULPING INDUSTRY

2.1 INTRODUCTION

Currently there are about 120 kraft pulp mills located in 28 States throughout the United States. The areas of greatest density are the Southeast, the Northwest, and the Northeast, in descending order. A list of all kraft pulp mills currently operating in the United States is included in Appendix E.

The main product of the kraft pulping industry is wood cellulose or pulp. Nearly all of the 32,342,000 tons of kraft pulp produced in 1974 was used to make paper, linerboard and similar products. The December 1975 market value of semi-bleached kraft pulp was about 350 dollars per ton. Plant size ranges from about 180 to 2550 tons of pulp per day with an average pulp production per mill of about 770 tons per day.

During 1973 about 210,000 people were employed by the industry in integrated pulp and paper mills and non-integrated pulp mills. Total wages were about $2,100,000,000. Approximately 70 percent of the pulp produced in the United States is produced by the kraft process.

Due to the rapid growth rate of the industry, kraft mills are a particularly attractive source category for new source performance standards (NSPS). Between 1956 and 1975 the growth rate of the industry was 5.5 percent per year. It is projected that kraft pulp production will increase at a rate of 2.5 percent per year between 1975 and 1978. However, it is also projected that the industry will return to a higher growth rate by 1980.

Kraft pulp mills can be significant sources of odorous gases and particulate emissions. These odors are offensive and sometimes carry twenty miles downwind of a mill, subjecting an entire town to foul odors from a single poorly controlled mill. Because of the large areas affected, kraft pulp mills have prompted interstate abatement activities and have caused international problems. The State of Vermont sued the State of New York and International Paper Company over the emissions from the pulp mill at Ticonderoga, New York. The United States Supreme Court involved EPA as a friend of the Court for the purpose of supplying technical information, although EPA did not have NSPS or standards on retrofitting existing sources. Other border areas where kraft pulp mills have stimulated EPA activity in the past include Lewiston, Idaho - Clarkston, Washington; International Falls, Minnesota - Fort Frances, Ontario; Fernandina Beach, Florida - St. Mary's, Georgia; and Luke, Maryland - Keyser, West Virginia.

Gaseous emissions from kraft mills are principally hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and sulfur dioxide. The particulate emissions are largely sodium sulfate from the recovery furnace, smelt tank, and lime kiln, as well as calcium compounds from the lime kiln.

Hydrogen sulfide and organic sulfides, when taken as a group, are called total reduced sulfur (TRS). They are extremely odorous and can be detected at concentrations of a few parts per billion. Significant sources of TRS in a kraft pulp mill which are candidates for new source performance standards are the recovery furnace system, lime kiln, smelt dissolving tank, digester system, multiple-effect evaporator system, black liquor oxidation system, brown stock washer system, and condensate stripping system.

In an Agency-sponsored study, completed in 1973, it was estimated that the average United States mill emits approximately 4.8 pounds of TRS per ton of air-dried pulp (lb TRS/T ADP) produced.[1] National annual TRS emissions from kraft pulp mills using this emission factor and the total pulp produced in 1974 are about 77,600 tons. The typical state standard for the states that have TRS standards is 1.3 lbs TRS/T ADP. A well controlled mill emits only 0.25 lb TRS/T ADP. Compared to a typical state standard, this is an emission reduction of 81 percent; and compared to the average mill in the United States, it is a reduction of 95 percent.

Significant sources of particulate emissions which are candidates for new source performance standards are the recovery furnace system, lime kiln, and smelt dissolving tank. Bark and power boilers are not presently included but will be considered with other boilers under a separate new source performance standard. Development of standards of performance forparticulate matter will significantly reduce emissions over present control levels. Only a limited number of recovery furnaces have installed highly efficient control systems. Many new furances that are designed to reduce odors by eliminating the direct-contact evaporator have created collection problems for electrostatic precipitators. Elimination of the direct-contact evaporator increases the particulate loading to the ESP and changes the physical characteristics of the dust. However, properly designed precipitators have been shown to be able to solve this problem. One domestic mill has successfully used an ESP to control particulate emissions from the lime kiln. There has been little additional effort by the industry to solve the problems sometimes encountered with the use of a precipitator or to install more efficient lime kiln collectors. The average United States mill emits about 5.5 pounds of particulate per ton of air-dried pulp and this is also representative of the typical state standard. A well controlled mill emits only 2.8 lb/T ADP. National emissions of particulates from kraft pulp mills are about 89,000 tons per year and would be reduced by about 49 percent if the best systems of emission reduction were applied to recovery furnaces, lime kilns, and smelt dissolving tanks.

Kraft pulp mills are also sources of SO_2, NO_x, and CO emissions. The recovery furnace is the major source of SO_2. The lime kiln and bark or power boilers have also been identified as sources of SO_2. Bark or power boilers are not covered by the proposed standards and may be covered under a separate industry category. EPA tests on two recovery furnaces and three lime kilns show emission levels of SO_2 of about 3.9 lb/T ADP (about 70 ppm) and 0.3 lb/T ADP (about 30 ppm) respectively. Standards for control of SO_2 emissions from recovery furnaces and lime kilns are not being proposed since the best demonstrated control techniques, considering costs, has not been identified for these facilities.

Recovery furnaces and lime kilns are also sources of CO and NO_x. CO emissions were measured by EPA on two recovery furnaces and showed levels of about 2.5 lb/T ADP (about 100 ppm). CO emissions from lime kilns average about 10 lb/T ADP. Presently there are no state regulations specific for control of CO emissions from kraft mill recovery furnaces or lime kilns. Standards for CO emissions from these two affected facilities are not being proposed since no control techniques have been demonstrated in the kraft pulping industry.

EPA tests on two recovery furnaces showed NO_x levels of about 1.9 lb/T ADP (about 50 ppm). No data are available on NO_x emissions from lime kilns at kraft pulp mills. However, EPA tests on three lime kilns used in the lime industry indicated NO_x emissions of about 200 ppm. Presently there are no state regulations for control of NO_x emissions from recovery furnaces or lime kilns at kraft pulp mills. NO_x standards are not being proposed because there is no available emission control technology for NO_x which has been demonstrated for these facilities.

2.2 DESCRIPTION OF THE KRAFT PULPING PROCESS AND AFFECTED FACILITIES

2.2.1 General Description

The process for producing kraft pulp from wood is shown in Figure 2-1. In the process, wood chips are cooked (digested) at an elevated temperature and pressure in "white liquor", a water solution of sodium sulfide (Na_2S) and sodium hydroxide ($NaOH$). The white liquor chemically dissolves lignin (the material that bonds the cellulose fibers together) from the wood. The remaining cellulose (pulp) is filtered from the spent cooking liquor, washed with water, and made into paper.

The balance of the process is designed to recover both cooking chemicals and heat. Spent cooking liquor and the pulp wash water are combined to form a weak black liquor which is concentrated in multiple-effect evaporators to about 65 percent solids, and then fired in a recovery furnace. There

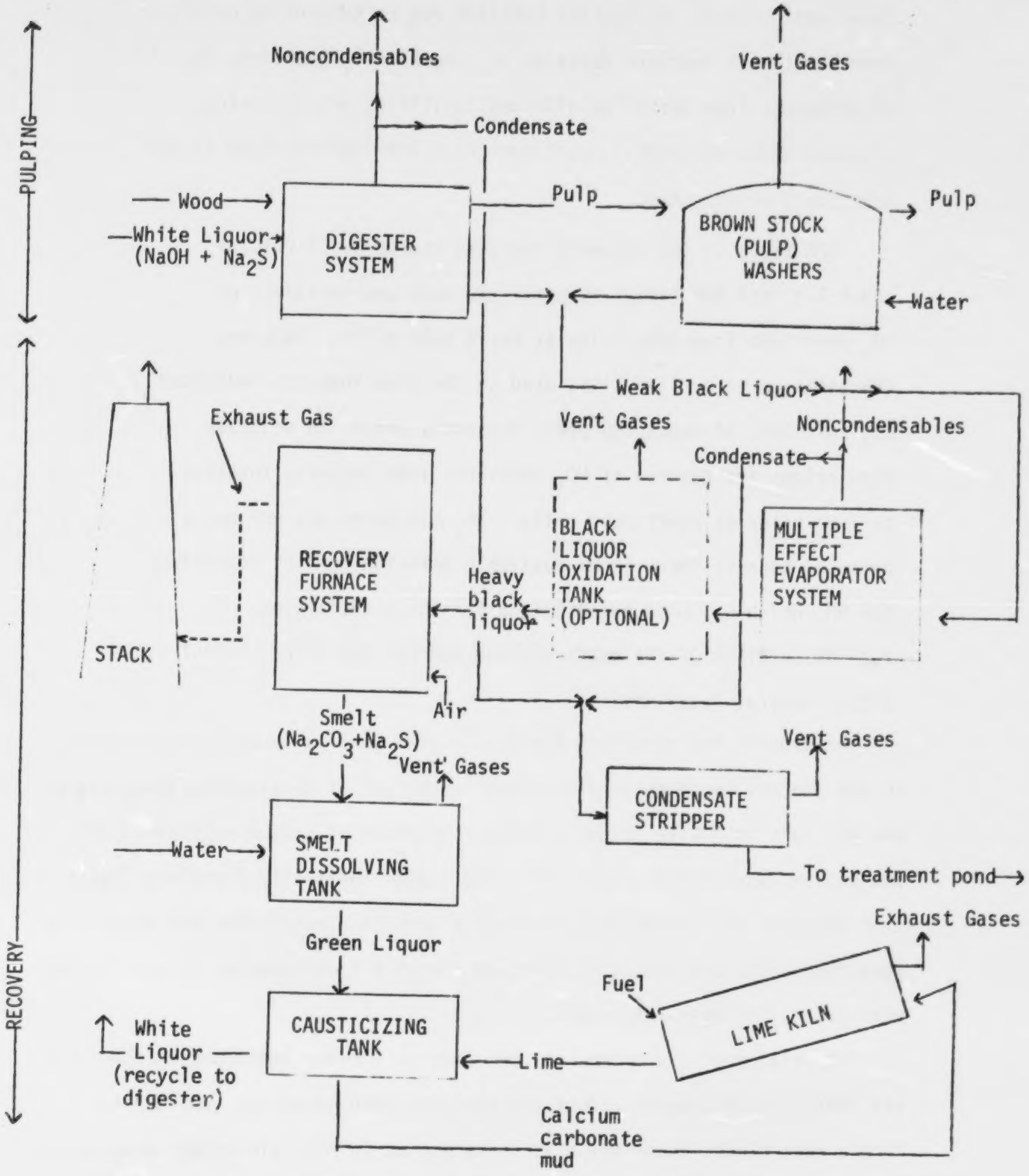
PULPING
RECOVERY
Noncondensables
Condensate
Vent Gases
Wood
White Liquor (NaOH + Na2S)
DIGESTER SYSTEM
Pulp
BROWN STOCK (PULP) WASHERS
Pulp
Water
Weak Black Liquor
Exhaust Gas
Vent Gases
Noncondensables
Condensate
STACK
RECOVERY FURNACE SYSTEM
Heavy black liquor
BLACK LIQUOR OXIDATION TANK (OPTIONAL)
MULTIPLE EFFECT EVAPORATOR SYSTEM
Air
Smelt (Na2CO3+Na2S)
Vent Gases
Vent Gases
CONDENSATE STRIPPER
To treatment pond
Water
SMELT DISSOLVING TANK
Green Liquor
Exhaust Gases
Fuel
LIME KILN
White Liquor (recycle to digester)
CAUSTICIZING TANK
Lime
Calcium carbonate mud

Figure 2-1. Kraft pulping process

are two main types of recovery furnace systems in use in the industry: the direct-contact evaporator system and the newer indirect-contact or "low odor," system. When the conventional direct-contact system is employed, oxidation of the concentrated black liquor prior to combustion in the recovery furnace is required to minimize TRS emissions. Combustion of the wood lignin dissolved in the black liquor provides heat for generating process steam and converting sodium sulfate (Na_2SO_4) to Na_2S. To make up for chemicals lost in the operating cycle, salt cake (sodium sulfate) is usually added to the concentrated black liquor before it is sprayed into the furnace.

The smelt, consisting of sodium carbonate (Na_2CO_3) and sodium sulfide, is dissolved in water to from green liquor which is transferred to a causticizing tank where quicklime (CaO) is added to convert the sodium carbonate to sodium hydroxide. Formation of the sodium hydroxide completes the regeneration of white liquor, which is returned to the digester. A calcium carbonate mud precipitates from the causticizing tank and is calcined in a kiln to regenerate quicklime. The condensate streams from the digester system and multiple-effect evaporator system usually contains dissolved TRS gases. These gases may be removed from the stream prior to discharge with a condensate stripping system using either air or steam in a stripping column.

2.2.2 Digester System

Wood chips are digested at about 170 to 175°C at pressure ranging from 100 to 135 pounds per square inch gauge (psig). Gases formed during digestion are vented in order to maintain the proper cooking pressure within the unit. At some mills these gases are first cooled to condense and recover turpentine before venting. The condenser cooling water recovers the heat and may be used in some other process. At the end of the cooking cycle, contents of the digester are transferred to an atmospheric tank usually referred to as a blow tank. Steam and other gases that flash from the blow tank are piped to a condenser to permit heat recovery. The noncondensable gases from the relief system and the blow tank vent may contain TRS concentrations as high as 26,000 ppm.[2] Both streams are sometimes referred to as digester "noncondensables". Uncontrolled TRS emissions from a typical digester system (1000 tons/day) average about 60 lb/hr (1.5 lb/T ADP) at a concentration of 9500 ppm.[2] Operating variables that have been shown to affect TRS emissions from digester systems are the black liquor recycle rate, cook duration, cooking liquor sulfidity (percentage of sodium sulfide to total alkali, Na_2S and NaOH, in white liquor), and residual alkali level. Presently five states require incineration of the digester noncondensables.

2.2.3 Brown Stock Washer System

Pulp from the digesters is washed countercurrently with water in several sequential stages. On leaving each stage, the pulp is dried on a vacuum filter, with the water draining into filtrate tanks. Some washer systems are hooded to collect the vapors steaming off the open washers. TRS emissions from a washer system average about 0.1 lb/T ADP (5-37 ppm) in the hood vent gas and about 0.2 lb/T ADP (240-600 ppm) in the filtrate tank (under) vent.[3]

Brown stock washer TRS emissions have been shown to be affected by the wash water source, water temperature, degree of agitation and turbulence in filtrate tank, and blow tank pulp consistency.[3] Presently one state requires incineration of the gases from the brown stock washer system.[4]

2.2.4 Black Liquor Oxidation Tank

Black liquor oxidation is designed to decrease the emission from the direct-contact evaporator by producing a negligible sodium sulfide concentration in the black liquor. Black liquor oxidation is the practice of oxidizing the sodium sulfide to sodium thiosulfate or a higher oxidation state in either weak or strong black liquor, using either oxygen or air. As previously mentioned, sodium sulfide that is present in the black liquor will react with SO_2 and CO_2 in the recovery furnace gases to produce hydrogen sulfide. In these mills which oxidize black liquor, air is most often used. Sparging reactors, packed towers, and bubble tray columns have been used in single or multiple stages to provide intimate contact between the liquor and air. During the process the air strips out some reduced sulfur compounds from the liquor. TRS emissions are principally dimethyl sulfide and dimethyl disulfide and generally are emitted in the range of 0.08 to 0.13 lb/T ADP (about 35 ppm).[5] Oxidation systems that use only oxygen have the advantage of emitting virtually no off-gases because the total gas stream reacts in the sparge system.

Black liquor oxidation system TRS concentrations are affected by the sulfide content, residence time in system and temperature of the black liquor. Presently there are no state regulations controlling the TRS emissions from black liquor oxidation systems.

2.2.5 Multiple-Effect Evaporator System

Spent cooking liquor from the digester is combined with the pulp washer discharge to form weak (dilute) black liquor. Multiple-effect evaporators are utilized to concentrate the weak black liquor from 12-18 percent solids to 40-55 percent solids. Concentration of the black liquor is necessary to facilitate combustion of the dissolved organic material in the recovery furnace. During the concentration, all of the gases are routed through a condenser. The noncondensable gases consist of air drawn in through system leaks and reduced sulfur compounds that were either in the dilute black liquor or formed during the evaporation process. TRS emissions from the multiple-effect evaporators can be as high as 44,000 ppm. Uncontrolled TRS emissions from a typical evaporator system (1000 tons of pulp/day) average about 42 lb/hr (1.0 lb/T ADP) at a concentration of 6800 ppm.[6]

The type of condenser used can influence the TRS concentrations. Certain types of condensers (e.g. barometric) allow the noncondensable gases and the condensate to mix, resulting in a limited quantity of hydrogen sulfide (H_2S) and methyl mercaptan gases to be dissolved in the water. This reduces the TRS concentration from the system but increases the sulfide level in the condensate. Sulfidity and pH of the weak black liquor also tend to have an effect on the TRS concentration from the multiple-effect evaporators.

Presently five states require incineration of the noncondensables from the multiple effect evaporators.

2.2.6 Recovery Furnace System

In the recovery furnace, concentrated black liquor is burned to produce a smelt of sodium carbonate and sodium sulfide that is used to reconstitute cooking liquor. Steam is produced as a by-product.

There are two main types of recovery furnace systems in use in the industry. The first type employs a direct-contact evaporator to provide the final stage of evaporation for the black liquor; this type is called a conventional or direct-contact system, and is shown in Figure 2-2. The

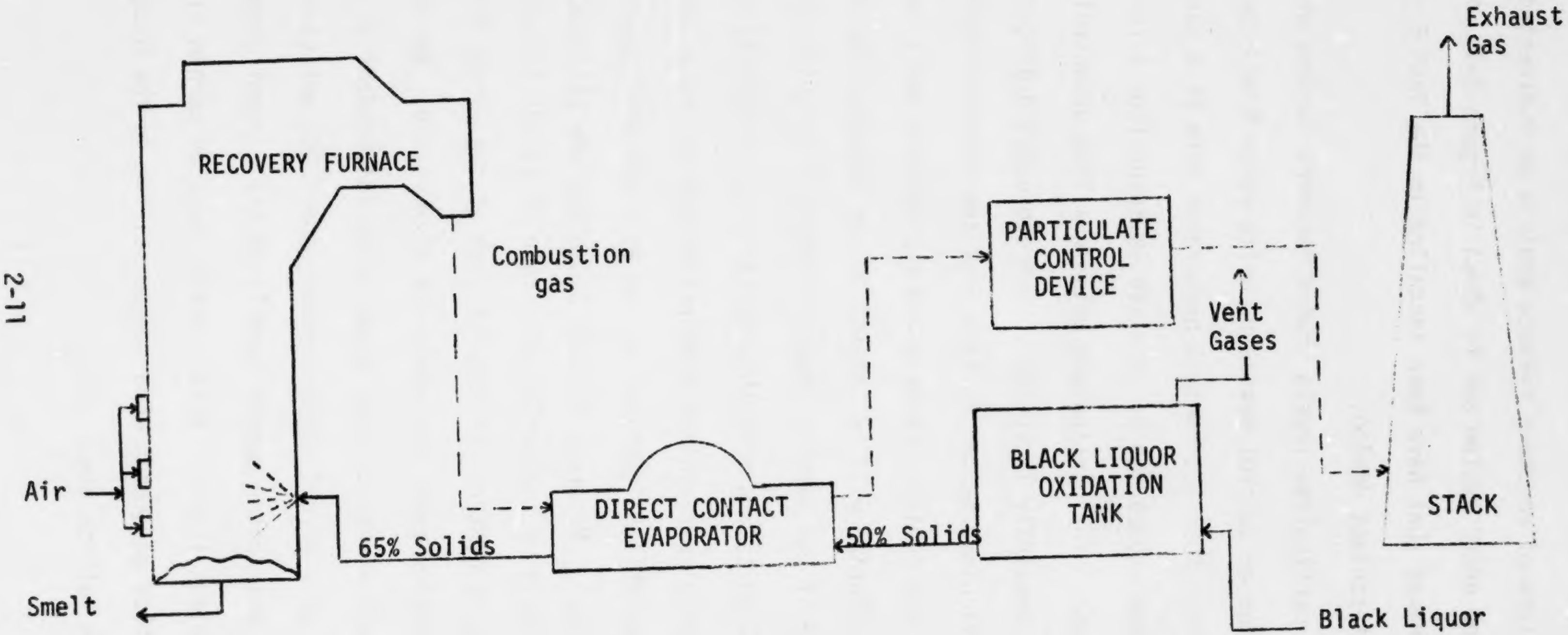
Exhaust Gas
RECOVERY FURNACE
Combustion gas
PARTICULATE CONTROL DEVICE
Vent Gases
Air
BLACK LIQUOR OXIDATION TANK
STACK
DIRECT CONTACT EVAPORATOR
65% Solids
50% Solids
Smelt
Black Liquor

Figure 2-2. Direct Contact (Conventional) Recovery Furnace System With Black Liquor Oxidation

second type of recovery furnace employs an indirect-contact, direct-fired, or a "low odor" system and is shown in Figure 2-3. About 75 percent of the new furnaces that have been installed in the last 5 years are of the indirect-contact design.

The particulate levels from a recovery furnace prior to a direct contact evaporator or control device normally range from 8 to 12 gr/dscf (200 to 450 lb/T ADP). A direct contact evaporator acts as a particulate control device and reduce the particulate emission from a furnace system by about 50 percent. The particulate emissions from uncontrolled recovery furnace systems presently in operation average about 3.81 gr/dscf (180 lb/T ADP).[7] The particulate matter emitted from the recovery furnace consists of sodium sulfate and sodium carbonate and may contain small amounts of sodium chloride. Sodium chloride will be present if the pulpwood has been stored in saline water or if the make-up chemicals contain chloride impurities.

TRS emissions from this facility may originate in either the furnace or in the direct-contact evaporators and may be as high as several hundred parts per million (ppm) or as low as 1 ppm when controlled by careful furnace operation.[8] Recovery furnace emissions are affected by the quantity and distribution of combustion air, rate of solids (concentrated black liquor) feed, spray pattern and droplet size of the liquor fed, turbulence in the oxidation zone, and smelt bed disturbance. The effect of these variables on TRS emissions has been shown to be independent of the presence or absence of a direct contact evaporator. TRS emissions from the direct-contact evaporator depend largely on the concentration of sodium sulfide in the black liquor. Acidic gases, such as carbon dioxide and sulfur dioxide, in the flue gas react with sodium sulfide in the black liquor to form hydrogen sulfide gas.

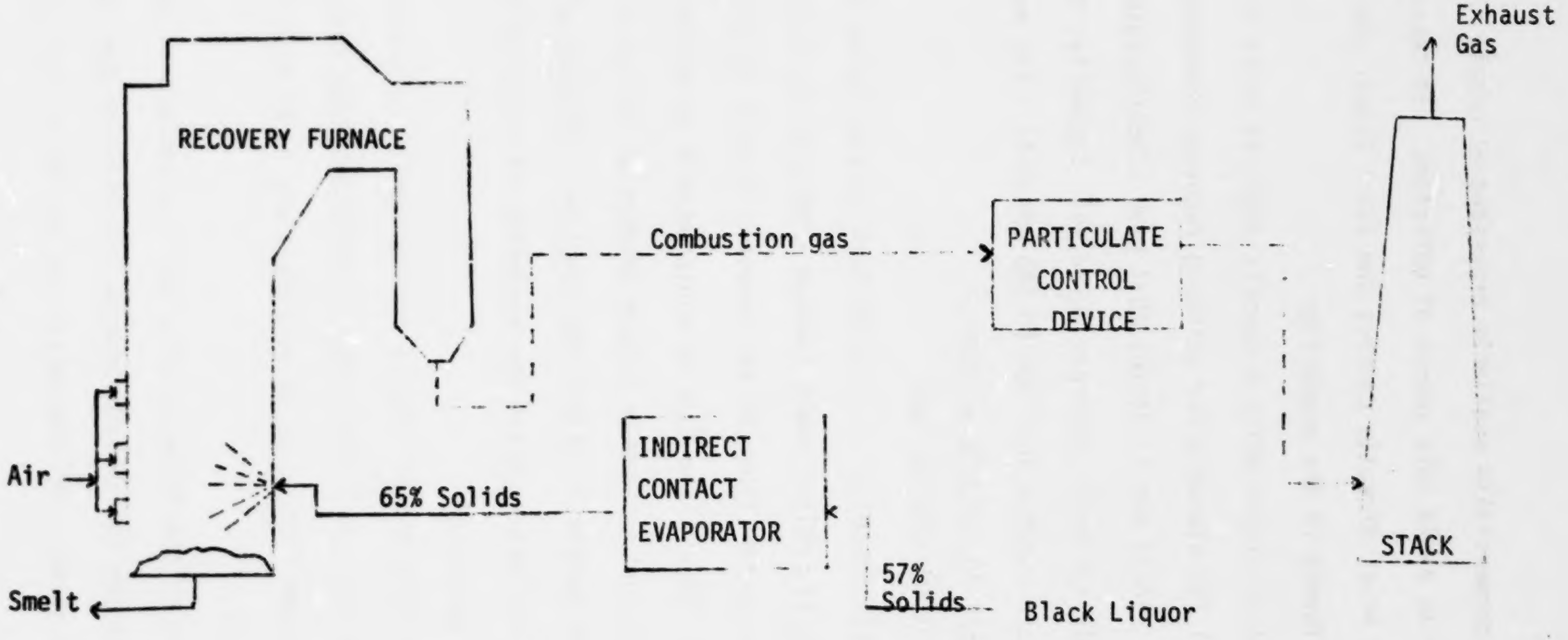
RECOVERY FURNACE
Air
Smelt
65% Solids
Combustion gas
INDIRECT CONTACT EVAPORATOR
57% Solids
Black Liquor
PARTICULATE CONTROL DEVICE
Exhaust Gas
STACK

Figure 2-3. Indirect contact recovery furnace system.

Four commercially available processes eliminate the direct-contact evaporator to avoid this source of emissions. In these systems, the furnace flue gases never directly contact the black liquor and hydrogen sulfide cannot be formed in the evaporator.

Of the 12 states which presently regulate kraft mill TRS emissions, the typical TRS standard for existing recovery furnaces is 17.5 ppm (0.5 lb/T ADP). There are 12 states that have a particulate standard specifically for kraft recovery furnaces. Typically, the state standards are about 4 lb/T ADP (0.085 gr/SDCF). The most stringent is 2.75 lbs/T ADP (0.058 gr/SDCF).[9]

2.2.7 Smelt Dissolving Tank

The smelt dissolver is a large tank located below the recovery furnace hearth. In it, molten smelt (sodium carbonate and sodium sulfide) that accumulates on the floor of the recovery furnace is dissolved in water to form green liquor. The tank is equipped with an agitator to assist dissolution, and a steam or liquid shatterjet system to break up the smelt stream before it enters the solution. Contact of the molten smelt with the water causes the evolution of large volumes of steam, which must be vented.

Particulate matter (finely divided smelt) is entrained in the vapor that leaves the tank. Uncontrolled emissions from a typical smelt dissolving tank (1000 tons of pulp/day) may be as high as 380 lb/hr (8.0 lb/T ADP).[1]

Because of the presence of a small percentage of reduced sulfur compounds in the smelt, some odorous materials escape the tank with the flashed steam. TRS concentrations may be as high as about 800 ppm and as low as non-detectable.[11] Several factors have been shown to affect the TRS emissions from this facility. Among these that affect the emissions from the tank are the sulfide content of the primary water in the tank itself, the turbulence of the dissolving water, and the sulfide content of the smelt entering the tank. It is also possible that TRS-contaminated gases can flow from the smelt pour spout of the recovery furnace and be emitted from the smelt tank. TRS can also be generated from the particulate scrubber. Factors that affect the generation of TRS from this unit are pH and sulfide content of the water and the sulfide content of the collected particulate.

Presently ten states have regulations to control the particulate emissions from smelt dissolving tanks. These regulations are typically 0.5 lb/T ADP (0.087 gr/SDCF). No state has a TRS regulation specifically for smelt dissolving tanks.

2.2.8 Lime Kiln

The lime kiln is an essential element of the closed-loop system that converts the green liquor solution of sodium carbonate and sodium sulfide to white liquor. The kiln calcines the lime mud (calcium carbonate which precipitates from the causticizer) to produce calcium oxide (quicklime, CaO) for recausticizing the green liquor. The lime sludge typically enters as a 55 to 60 percent solid-water slurry.

The kraft pulping industry typically uses large rotary kilns that are capable of producing 40 to 400 tons per day of quicklime. Fluidized bed calciners are presently being used at four pulp mills but their production rate at this time is under 150 tons/day. These fluidized bed calciners only produce about one percent of the total quicklime produced in the kraft industry.[12]

The lime kilns used in the industry differ from those used in the lime manufacturing industry in that the calcium carbonate is generally fed as a mud (sludge), containing 40 to 45 percent water instead of as a solid (limestone). This mud contains a small percentage of sodium sulfide which affects the size distribution and composition of the particulate in the exhaust gases. This sodium sulfide is not present in the limestone used in the lime industry. Dry collectors, such as electrostatic precipitators, and baghouses, are used extensively in the lime manufacturing industry but presently only one kraft pulp mill uses a dry collector (electrostatic precipitator).

TRS emissions can originate in the lime kiln proper and in the kiln scrubber which is normally installed to control particulate emissions. TRS emissions originating in the lime kilns are affected by several factors: the oxygen content of the exhaust stream, the kiln length-to-diameter ratio, the sulfide content of the lime mud, the cold-end exit gas temperature, and the practice of simultaneously burning the sulfur-bearing materials contained in the lime mud (e.g. green liquor dregs; the impurities resulting from clarifying the green liquor).[13]

Operating variables which govern the contribution of TRS emissions from the particulate control device are the residual sulfide content of scrubber make-up water (depending on the source of the water), the recirculation rate within the scrubber, the pH of the scrubbing solution, and the sulfide content of the particulate collected. Depending on these factors, the particulate control device may contribute as much as 100 ppm (0.5 lb/T ADP) to the kiln exhaust.[13]

Lime kiln particulate emissions consist principally of sodium salts, calcium carbonate, and calcium oxide. The sodium salt emissions results primarily from sodium compounds that are retained in the mud because of less efficient or incomplete washing. Therefore, the particulate emissions are affected by the efficiency of the mud washing system (higher than normal sodium levels in mud result in higher particulate emissions). The calcium particles result from entrainment, and therefore the emissions are affected by the gas velocity and turbulence in the kiln. Uncontrolled particulate emissions from a typical lime kiln (1000 ton of pulp/day) are about 3300 lb/hr (80 lb/T ADP) at a concentration of 9.7 gr/sdcf.[1]

Presently only three states have TRS regulations specifically for lime kilns. These standards are typically 40 ppm (0.2 lb/T ADP), and the most stringent is 10 ppm. Twelve states have particulate standards specifically for kraft mill lime kilns. Typically, these standards are about 1.0 lb/T ADP (0.12 gr/dscf), and the most stringent is 0.5 lb/T ADP (0.061 gr/dscf).[8]

2.2.9 Condensate Stripping System

When digester and multiple-effect evaporator off-gases are condensed, some TRS gases are partially dissolved in the condensate. Prior to being discharged to the water treatment ponds, the TRS compounds can be stripped from the digester and evaporator condensate with either steam or air in a stripping column. Uncontrolled TRS emissions from a condensate stripper are estimated to be about 2 lb/T ADP (5000 ppm).[14] Currently only one state requires incineration of gases from the condensate stripping system.[4]

References

1. *Atmospheric Emissions from the Pulp and Paper Manufacturing Industry*, EPA-450/1-73-002, September 1973, (Also published as a NCASI Technical Bulletin No. 69, February 1974).
2. Reference No. 1, Table 3, p. 15.
3. *Factors Affecting Emission of Odorous Sulfur Compounds From Miscellaneous Kraft Process Sources*; NCASI Technical Bulletin No. 60, March 1972.
4. Hovey, Harry H. Jr., New York State Department of Environmental Conservation, April 5, 1974, letter to Mr. Jean J. Schueneman, EPA.
5. Reference No. 1, Table 20, p. 46.
6. Reference No. 1, Table 7, p. 20.
7. Reference No. 1, pages 34-37.
8. *Factors Affecting Reduced Sulfur Emissions from the Kraft Recovery Furnace and Direct Contact Evaporator*, NCASI Technical Bulletin No. 44, December 1969.
9. *Analysis of Final State Implementation Plans - Rules and Regulation*, U.S. Environmental Protection Agency, Research Triangle Park, N.C., July 1972.
10. Reference No. 1, pages 48-50.
11. Reference No. 1, Tables 26 and A-3.
12. *Dorr-Oliver Fluosolids System for Lime Mud Reburning in Connection with Recausticizing in Kraft Mills*, Dorr-Oliver Reprint No. 7353.
13. *Suggested Procedures for the Conduct of Lime Kiln Studies to Define Emissions of Reduced Sulfur Through Control of Kiln and Scrubber Operating Variables*, NCASI Special Report No. 70-71, January 1971.
14. *Air Emission Control Program for Hoerner Waldorf Corporation Mill Expansion Missoula, Montana*; submitted by Hoerner Waldorf Corporation to Montana State, March 12, 1974.

3. SUMMARY OF THE PROCEDURE FOR THE DEVELOPMENT OF THE PROPOSED STANDARDS

3.1 LITERATURE REVIEW AND INDUSTRIAL CONTACTS

Information initially used in the development of the proposed standards of performance for the kraft pulping industry was obtained from two studies performed by research and engineering companies under contract to EPA.[1,2] These studies provide information on trends in the kraft pulping industry, industry statistics, economics, processes and emissions, and emission control technology and procedures.

A more recent study has provided further information used in the development of the proposed standards. This study was a joint program by the National Council of the Paper Industry for Air and Stream Improvement (NCASI) and EPA, and was primarily concerned with emissions and control techniques used in the kraft pulping industry. The study utilized a survey of the industry (performed with questionnaires), special studies reported in NCASI Technical Bulletins, other literature sources, and a field sampling program conducted by EPA. The study provided information on control techniques and range of emissions for each of the operations involved in the chemical pulping processes.[3]

During the standards development program additional literature was also obtained and reviewed, and information was obtained from four State and local air pollution control agencies and from manufacturers of process equipment and emission control equipment. Meetings were held with representatives of the industry and the NCASI to obtain additional information useful in the development of standards.

3.2 PLANT INSPECTIONS

EPA engineers visited 26 kraft pulp mills to identify those mills which appeared to utilize the best systems of emission reduction on any of the affected facilities to which the proposed standards apply. During these visits, information and data were obtained on each of the affected facilities. The well-controlled facilities that were tested were chosen on the basis of the type of control device used, its operating conditions, available data on emissions, and the feasibility of conducting tests.

3.3 SAMPLING AND ANALYTICAL TECHNIQUES

3.3.1 Particulate Sampling

EPA Reference Method 5 was used to gather the data used to support the proposed particulate standards for the recovery furnace, the smelt dissolving tank, and the lime kiln. The provisions of this method were originally published in the Federal Register on December 23, 1971 (36 FR 24877). Minor revisions of the method have been published since then.

The method provides detailed sampling methodology and equipment specifications. The method also provides specific procedures for the measurement of moisture content and volume of gas sampled, and permits continuous assurance of isokinetic sampling.

EPA Reference Method 2 is used to measure gas flow which is required to calculate the mass emission rate. Since the proposed particulate standard for the smelt dissolving tank limits the mass emission rate rather than the concentration, an accurate measure of the flow rate is required.

3.3.2 TRS Sampling and Analysis

Since no method for measurement of total reduced sulfur had been standardized at the inception of the kraft mill program, it was necessary to develop an effective and reliable method. Several methods were surveyed through literature reviews, contact with industry personnel, and review of previous research and evaluation of analytical techniques by EPA.

The methods surveyed fell into four main categories: colorimetry, direct spectrophotometry, coulometry, and gas chromotography. The gas chromotography and flame photometric detector (GC/FPD) was considered to be the most promising and was selected for field evaluation.

As a result of the field experience of testing TRS compounds at kraft mills, Method 16, "Semicontinuous Determination of Sulfur Emissions at Stationary Sources," was prepared for determining compliance with the proposed standards. This method requires the use of the GC/FPD system developed during the test program. Design specifications for the required dilution system, calibration technique, and instrumentation that was considered necessary to insure accuracy, precision, and reliability are specified.

3.4 EMISSION MEASUREMENT PROGRAM

EPA performed emissions measurements at 12 domestic kraft pulp mills. Included are particulate tests on five recovery furnaces, four smelt dissolving tanks, and four lime kilns; and TRS tests on three recovery furnaces, two smelt dissolving tanks, three lime kilns, and one incinerator for noncondensable gases from multiple effect evaporator systems and digester systems.

3.4.1 Particulate Test Program

Of the recovery furnaces tested for particulates, two were direct fired types and three had direct contact evaporators. At least one complete sootblowing cycle was included within each sampling period. During tests, the control system and furnace operation were monitored to detect process upsets or abnormal operation which would affect the test results. Three or more individual test runs were made for each furnace.

During the four smelt tank tests, the control system and the recovery furnace operation were monitored to detect process upsets or abnormal operation which might affect the test results. The furnace operation was monitored because the flow of smelt to the dissolving tank cannot be monitored directly and the best indication of a normal smelt flow rate is normal operation of the recovery furnace. Three or more individual test runs were made for each smelt dissolving tank.

During the four lime kiln tests, both the control system and the lime kiln operations were monitored to detect process upsets or abnormal operation which might affect the test results. On three kilns, three test runs were conducted on each type of fuel (gas and oil) used in the kiln, totalling six test runs for each kiln. Three test runs were made on the fourth kiln which only burns natural gas.

Opacity measurements were also taken during the particulate testing whenever possible and were usually conducted over the length of the particulate tests. All readings were taken in accordance with EPA Reference Method 9 techniques. Visible emissions readings were recorded on four recovery furnace stacks during the particulate test runs. Readings were also attempted to be made on three smelt dissolving tanks and one lime kiln. Although some data were recorded, it was determined that due to the presence of steam plumes, the readings did not support the setting of a visible emissions standard for the smelt dissolving tank or the lime kiln.

3.4.2 TRS Test Program

Tests were conducted on three recovery furnaces (one indirect contact furnace and two with a direct contact evaporator), two smelt dissolving tanks, three lime kilns, and the one incinerator for noncondensables. During these tests, the control system and the operation of the respective facilities were monitored to detect process upsets or abnormal operation which might affect the test results. Three to six individual test runs were made during each of these tests. The duration of each test run was four hours.

NOTE: A chronological history of the development and evolution of the proposed standards which includes all significant plant visits, meetings, and project milestones is described in Appendix A, Evolution of the Proposed Standards.

References

1. Control of Atmospheric Emissions in the Wood Pulping Industry, Environmental Engineering, Inc.; and J. E. Sirrine Company, Contract No. CPA 22-69-18, March 15, 1970.

2. Background Information for Establishment of National Standards of Performance for New Sources: Pulp and Paper Industry, (Draft Copy), Environmental Engineering, Inc., Contract No. CPA 70-042, Task Order No. 2, March 15, 1971.

3. Atmospheric Emissions from the Pulp and Paper Manufacturing Industry, EPA-450/1-73-002, September 1973, (also published by NCASI as Technical Bulletin No. 69, February 1974).

4. EMISSION CONTROL TECHNOLOGY

The alternative methods of emission control applicable to each affected facility at kraft pulp mills are presented in this chapter. Where available, emission data obtained from the joint study conducted by EPA and NCASI are also presented.[1] These data illustrate the range of control levels that have been applied to affected facilities at the domestic mills studied. Alternative emission control systems, combinations of the best control techniques, which are considered as likely candidates for the best system of emission reduction, considering costs, are summarized.

4.1 PARTICULATE CONTROL

4.1.1 Recovery Furnace

Nearly all recovery furnaces employ electrostatic precipitators as their primary particulate control devices. The degree of control provided, however, varies among the individual units. Design efficiencies range from about 90 percent on older precipitators to above 99.5 percent on recent installations.

Until recently, almost all recovery furnace systems incorporated a direct contact evaporator. Although the purpose of the evaporator is to concentrate black liquor, it may also scrub particulate matter from the gas stream. Depending on the type of direct-contact evaporator used, up to 50% of the particulate may be removed.

Most direct contact evaporators are the cascade type, in which the furnace gases pass over a trough filled with black liquor, which is scooped up by a rotating paddle wheel and then cascades through the gas stream. Some mills use cyclones or venturis as the direct contact evaporator. In these installations, the black liquor serves as the particulate scrubbing liquid. Sometimes two venturis are used in series to increase particulate collection, and in that case an electrostatic precipitator may not be required.

On some recovery furnaces scrubbers have been installed downstream from precipitators. In the United States this practice has been confined to upgrading existing units. In Sweden, the purpose of the backup scrubber has been to increase the heat recovery from the furnace gases. The scrubbers used are low energy sprays. Such scrubbers can effectively reduce the "snowing" (the emission of large white particles resembling snowflakes) from inefficient precipitators, but are probably ineffective against the small particles that escape from a well designed and operated precipitator. The principal cause of snowing is the electrode rapping done to dislodge collected material from collecting electrodes. Because salt cake particles tend to be light and fluffy, some of it is re-entrained in the gas stream and can escape the precipitator. The re-entrainment problem can be intensified if the gas flow through the precipitator is improperly distributed. A second cause of snowing is electrical sparking. When excessive sparking occurs, the basic collecting action of the precipitator is momentarily lost, and puffs of salt cake particles can escape. Overloading the precipitator by sootblowing or abnormal furnace operation can also cause snowing.[2]

Emission levels observed from various control systems are shown in Table 4.1. For each system there is a wide range of emissions. This table is based on data reported in a questionnaire survey.[3] The emission ranges are due to the variance in collection efficiency and design of the control systems.

In a meeting with EPA on March 7, 1975, the kraft pulping industry expressed concern that even with diligent maintenance the proposed particulate standard of 0.10 g/dscm (0.044 gr/dscf) for kraft recovery furnaces could not be achieved over the life of an electrostatic precipitator (ESP). The industry has little confidence that precipitator performance will meet design expectations. In support of their contention, case histories of precipitator performance were provided to EPA by individual companies. These cases are concerned with units that do not achieve design performance, with problems encountered during the fine turning of units in bringing them up to performance, and with the amount of maintenance required to maintain the performance of a precipitator. The industry feels that the performance of precipitator should be allowed to deteriorate until a sufficient amount of maintenance is necessary to justify shuting down the unit and performing the maintenance.

Weyerhauser Co., American Can Co., Brunswick Pulp and Paper Co., and Buckeye Cellulose all reported problems in the application of electrostatic precipitators for control of particulate emissions from kraft recovery furnaces.

Weyerhauser Co.[4] stated that their last three precipitator installations on indirect contact system recovery furnaces have not

Table 4.1. PARTICULATE EMISSIONS FROM VARIOUS RECOVERY FURNACE CONTROL SYSTEMS

Control system	Number of Units averaged	Emissions;(a) lb/T ADP		Emissions;(b) gr/dscf		Emissions;(c) g/dscm	
		Range	Median	Range	Median	Range	Median
Precipitator	87	1-95	14	0.02-2.0	0.3	0.05-4.5	0.69
Venturi	10	14-115	45	0.3-2.4	1.0	0.69-5.49	2.29
Precipitator & backup scrubber combination							
Precipitator only	7	6-88	23	0.1-1.9	0.5	0.229-4.35	1.14
Back-up scrubber	7	2-13	4	0.04-0.3	0.08	0.09-0.69	0.18

(a) Reference 1, pages 34-35

(b) Calculated from emissions in lb/T ADP on the basis of 1.0 gr/dscf = 47.3 lb/T ADP.

(c) Calculated from emissions in gr/dscf on the basis of 1.0 gr/dscf = 2.288 g/dscm.

met the level of the proposed standard even though the design basis of 99.5 percent should have been adequate. Extensive efforts have been made to bring the units into compliance and to overcome corrosion problems. One unit has been totally rebuilt at an estimated cost of 0.5 million dollars and a second unit is currently facing the same situation. The rebuilding of the second unit is expected to exceed the original costs. A third precipitator has been plagued by excessive wire breakage since startup. Weyerhauser reports that the manufacturer of the unit blames this problem on poor flue gas distribution at the inlet. Based on their experiences with three different manufacturers, Weyerhauser contends that the state of the art is not now adequate to meet a level of 0.10 g/dscm.

American Can Co.[5] has experienced similar problems. The first indirect contact evaporator system was installed at their Halsey, Oregon mill in 1969. American Can reported that during the period August 1, 1973, to March 1, 1974, it was necessary for American Can to notify the State Agency about 70 times that they were exceeding the particulate standard of 4 lb/ton due to a malfunction of the precipitator. Late in 1973 American Can spent approximately $50,000 for mechanical improvements on the precipitator. American Can stated that the maintenance of a precipitator on a kraft recovery furnace is a continuous ordeal for any kraft mill. Planned maintenance outages are necessary and it is difficult to predict when unplanned situations could occur. Routine maintenance expenses are also quite high.

Brunswick Pulp and Paper Co.[6] reports that shortly after start-up of their unit at Brunswick, Georgia, they were forced to replace the electric rappers on the collecting plates with pneumatic rappers. The original rappers did not produce sufficient rapping intensity to clear the plates of collected saltcake. It also became apparent after start-up that the scraper saltcake removal system had inadequate capacity. Other problems causing abnormal precipitator operation have resulted from troubles with electrical controls, broken wires and numerous instances of problems with liquor lines which began to fail during 1974. In all, there were 519 hours in 1974 during which abnormal operation was experienced requiring the process of cutting out one-half of the precipitator. Brunswick Pulp and Paper also experienced additional internal problems due to plugging of turning vanes and distribution plates, which caused channeling of the gas flow and reduced the precipitator effectiveness. Inaccessibility of the turning vanes requires cooling down the precipitator for maintenance. Clean out is now scheduled at least semi-annually. The best remedy thus far suggested involves the application of rappers to the turning vanes.

Brunswick mill personnel further stated that even a recently designed and installed high efficiency precipitator is subject to malfunction on an average of one day per week. These malfunctions can periodically occur more frequently. Therefore, they state it is important to recognize that abnormal operation can and does occur, and that allowance for unavoidable abnormal operation should be made in the proposed standards.

At the meeting between EPA and kraft pulp mill industry representatives on March 7, 1975, representatives of Buckeye Cellulose stated that the particulate emissions from their No. 2 recovery furnace, which was tested by EPA, increased by almost 10 times over a one-year period. Data obtained in February 1974 showed levels of 0.007 gr/dscf; data obtained in February 1975 showed levels of 0.06 gr/dscf. Buckeye attributed the increase to wire breakage within the precipitator.

Three precipitator manufacturers[7,8] were visited by EPA personnel to obtain their opinion concerning the kraft industry's position with regard to ESP performance on recovery furnaces. All three manufacturers stated that with a reasonable amount of maintenance electrostatic precipitators can achieve 0.10 g/dscm over the life of the unit. The manufacturers feel that some of the problems encountered by the industry were due to underdesign of the units or operation under conditions for which they were not designed. At a recent TAPPI conference, one vendor representative stated that if the precipitators had been adequately sized in the design that they would have been non-competitive with other bidders.[10] Most units being sold presently have design outlet loadings of 0.01 grain/acf (about 0.02 grain/dscf) for both conventional and low-odor units. They further stated that the performance problems with precipitators on indirect contact system furnaces are now recognized and that new basic parameters for both sizing and design have been established.

Since the characteristics of the particulate matter and the gases are reasonably constant from mill to mill, the problems encountered are with air distribution and patterns to minimize re-entrainment. Application of precipitators to the kraft industry is more demanding than in other industries. The dust collected in the kraft industry, especially from indirect contact systems, is more corrosive and sticky than that encountered in other industries. More intense rapping is required to remove the dust from the collecting surfaces. The manufacturers feel that some design changes are needed to improve the precipitator's ruggedness and extra maintenance will be required.

Concerning the problem of gradual deterioration of precipitator performance, the manufacturers were most emphatic in stating that a properly maintained precipitator should not deteriorate over the expected life of the unit. Problems encountered are usually due to operating the equipment at conditions for which it was not designed (i.e., higher gas volumes, higher inlet loadings, or lower inlet temperatures). For preventing corrosion, the manufacturers install insulation or heated shells to maintain the gas temperature through the precipitator. Corrosion resulting from low inlet temperature (below the acid dew point-280°F), frequent start-ups and shutdowns of the recovery furnace, or due to an ambient corrosive atmosphere is not dependent on the design of the unit.

The viewpoint of the manufacturers on the wire breakage encountered by the kraft industry is that wire breakage generally occurs soon after start-up, with a lessening in frequency as operating time increases. A precipitator is generally capable of losing 5 to 10 percent of the wires without a noticeable effect on the performance. One manufacturer believes that the rash of wire breakage reported are due to increased rapping intensity to improve performance.

This problem is most noticeable with indirect-contact furnaces that generate a stickier dust which is more difficult to remove from the collection surfaces. Some operators have replaced the original electric rapping system with more efficient high energy air vibrators. A maximum pressure at which these air vibrators should be operated will be recommended by the manufacturers.

A new design has been reported by one manufacturer which minimizes wire breakage and maintains high collection efficiency.[24] This design involves supporting the wires in a frame with fasteners every five feet. High energy rapping is possible with less loss of wires. They feel that this is a more dependable design than the weighted wire design typical of precipitators used in the kraft pulping industry today.

St. Regis' Tacoma, Washington mill currently uses a precipitator with this design. EPA tested this precipitator and reported particulate emissions below 0.02 g/dscm.[25] Additional data supplied by the state control agency show that the monthly particulate tests have been less than 0.10 g/dscm since the unit started operation in August 1973.[9] The main problems that have been encountered were one broken wire, burned out motors or bearings, and plugging of salt cake hoppers. The manufacturer estimates that approximately 240 man-hours of maintenance will be required per year on this type of unit.

A survey was conducted by an Air Pollution Control Association Committee on the maintenance requirements of precipitators.[11] The purpose of the survey was to establish the degree of satisfaction of the user with the equipment from an operational and a maintenance viewpoint. This survey indicated that, although there is obviously room for improvement on the part of precipitator manufacturers, the majority of the users are satisfied with the performance (73.5 percent satisfied) and maintenance (55 percent satisfied) of precipitators used in the wood pulping industry. These values are consistent with values from other industries (cement and utility).

On the basis of the industry and vendor data and comments, EPA has concluded that the application of electrostatic precipitators for control of particulate emissions from both direct-contact and indirect-contact recovery furnace systems is a feasible and proven application. The level of the proposed standard, 0.10 g/dscm, has been demonstrated on presently operating systems of both types. Provided the original design was adequate and a reasonable amount of maintenance is performed, the performance of the precipitator should not significantly deteriorate. Unusual conditions may, however, exist at some mills which may require more maintenance or create a greater corrosion problem.

4.1.2 Smelt Dissolving Tanks

The gases from most smelt dissolving tanks are vented through demister pads, fine wire mesh screens, about one foot thick. Demister pads are basically low energy scrubbers with collection efficiencies of about 80 percent. Droplets condensing from the gas collect on the screen, and are backflushed with water sprays to the dissolving tank. Several dissolving tanks are equipped with more efficient water scrubbers, such as low pressure drop venturis (6-8 inches of water), packed towers, and cyclones with water sprays. Efficiencies of these systems are about 95 percent. A few mills combine the dissolving tank gases with the recovery furnace gases, sending both streams to an electrostatic precipitator.

Emission data reported for 29 dissolving tanks range from 0.05 to 2.38 lb/T ADP (equivalent to about 0.009-0.4 gr/dscf) with a median of 1.0 lb/T ADP[12] (equivalent to about 0.17 gr/dscf). Available data reported in a questionnaire survey comparing the efficiencies of various scrubber systems are shown in Table 4.2.

4.1.3 Lime Kiln

Nearly all lime kilns are controlled with venturi scrubbers, with pressure drops ranging from 10 to 25 inches of water. These systems provide collection efficiencies of up to about 99 percent. Impingement scrubbers, with wetted baffles and water sprays, are used less frequently. The impingement scrubbers have pressure drops of 5-6 inches of water and provide collection efficiencies of only about 90 percent.

Electrostatic precipitators are found on some lime kilns operating in Sweden. Design efficiencies of these systems are about 99 percent. One United States mill has retrofitted a precipitator to serve three existing kilns.

Particulate emissions from lime kiln scrubbers range widely, depending on operating conditions--especially the scrubber pressure drop. Available data for 66 scrubbers show a range of 0.08 to 43 lb/T ADP, with a median of 2.7 lb/T ADP.[13] Available data reported in a questionnaire survey comparing the performance of the different control devices are shown in Table 4.3.

4.2 TRS CONTROL

4.2.1 Digester and Multiple-Effect Evaporator Systems

TRS emissions from the digester and multiple-effect evaporators will be considered together, since their emissions are normally combined

Table 4.2. PARTICULATE EMISSIONS FROM VARIOUS SMELT DISSOLVING TANK CONTROL SYSTEMS

Control system	Collection efficiency[a] %	Emission rate		
		lb/T ADP[a]	g/kg ADP[b]	gr/dscf[c]
Demister pad	72	0.052	0.03	0.009
	77	0.15	0.08	0.03
	78	0.63	0.32	0.1
	90	2.3	1.15	0.4
	93	1.2	0.60	0.2
	71	1.58	0.79	0.3
Demister pad plus shower	96	0.41	0.21	0.07
Demister pad plus packed tower	92	1.20	0.60	0.2
Packed tower	98	0.05	0.03	0.009

(a) Reference 3

(b) Calculated from emissions in lb/T ADP on the basis of 1.0 lb/T ADP = 0.5 g/kg ADP.

(c) Calculated from emissions in lb/T ADP on the basis of 1.0 gr/dscf = 5.76 lb/T ADP.

Table 4.3. PARTICULATE EMISSIONS FROM VARIOUS LIME KILN CONTROL SYSTEMS

	Impingement scrubber(a)			Venturi scrubbers(a)				Electrostatic Precipitator(c)		
	Outlet gr/dscf	Outlet(b) g/dscm	Outlet(d) lb/T ADP	Outlet gr/dscf	Outlet(b) g/dscm	Outlet(d) lb/T ADP		Outlet gr/dscf	Outlet(b) g/dscm	Outlet(d) lb/T ADP
	0.46	1.05	3.78	0.16	0.37	1.32		0.029	0.066	0.24
	0.43	0.98	3.53	1.00	2.29	8.22		0.088	0.201	0.73
	0.58	1.33	4.77	0.23	0.53	1.89	Avg.	0.058	0.134	0.48
	1.05	2.40	8.63	0.13	0.30	1.07				
	0.88	2.01	7.23	0.12	0.27	0.99				
	1.56	3.57	12.8	0.14	0.32	1.15				
	0.53	1.21	4.36	0.38	0.87	3.12				
				0.37	0.85	3.04				
Avg.	0.78	1.79	6.44	0.32	0.73	2.60				

(a) Reference 1, Table 27

(b) Computed on the basis: 1 gr/dscf = 2.288 g/dscm

(c) Reference 15

(d) Computed on the basis: 1 gr/dscf = 8.22 lb/T ADP for treatment. The noncondensable gases from these facilities are often vented directly to the atmosphere. For odor control an increasing number of mills presently burn the gases, most often in the lime kiln. Special gas-fired incinerators are also used, either as backup for the kiln when it is down, or as the regular control unit.

The blow gases from batch digesters come in strong bursts that may exceed the capacity of the lime kiln. Special gas handling equipment has been developed to smooth out the gas flows,[14] and is in use at many presently operating mills. Adjustable volume gas holders, with movable diaphragms or floating tops, receive the gas surges, and bleed a small steady stream to the kiln. Although the noncondensable gases form explosive mixtures in air, possible explosion hazards have been effectively minimized by the development of gas holding systems, flame arrestors, rupture disks, and flame-out controls. Incineration of these gases in existing process equipment such as the lime kiln is particularly attractive since no additional fuel is required to achieve effective emission control.

Scrubbers are used at a few mills to reduce TRS emissions. White liquor, the usual scrubbing medium, is effective for removing hydrogen sulfide and methyl mercaptan, but not dimethyl sulfide or dimethyl disulfide. At least 3 mills scrub the noncondensable gases prior to incineration in order to recover sulfur, condense steam, and remove turpentine vapors and mist, lessening the explosion hazards.

Combustion of noncondensable gases in a lime kiln or gas-fired incinerator provides nearly complete destruction of TRS compounds. During an EPA test on an incinerator burning noncondensables from digesters and multiple-effect evaporators, the unburned TRS residuals were less than

5 ppm (about 0.01 lb/T ADP). Scrubber efficiencies are much lower because only hydrogen sulfide and methyl mercaptan react with the alkaline medium. The composition of noncondensables is highly variable, but on the average, hydrogen sulfide and methyl mercaptan comprise about half the TRS compounds.[15] Alkaline scrubber efficiencies, therefore, will be roughly 50 percent and TRS emissions will be about 1 lb/T ADP.

4.2.2 Brown Stock (pulp) Washing System

Nearly all kraft mills vent the pulp washing system gases directly to the atmosphere. At least four mills in the United States and Canada, and several in Sweden, utilize the gases as combustion air in a recovery furnace.

The gas volume from the washer drums is large, about 150 CFM/TPD.[16] It may be reduced by enclosing the drums with tight hoods. Use as combustion air in a recovery furnace or power boiler is the most likely control alternative.

The gases vented from the filtrate tank have considerably less volume, about 6 CFM/TPD.[16] This stream can be incinerated in a lime kiln, or blended with the hood vent gas and burned in a recovery furnace. Combustion of the gases from these filtrate tanks would not result in any significant increase in fuel requirements.

Incineration is the only control method known to be practiced. As discussed in Chapter 6, TRS combustion residuals are very low, less than about 5 ppm (0.01 lb/T ADP).

4.2.3 Black Liquor Oxidation Systems

The vent gases from black liquor oxidation (BLO) systems are emitted directly to the atmosphere. Presently there are no control techniques being practiced to reduce TRS levels in these vent gases, but technology for eliminating these vent gases completely has been demonstrated.

There are apparently no technical or economic reasons to prevent controlling BLO systems by using the vent gases as combustion air in the recovery furnace. Incineration has proved highly effective at some mills in controlling similar streams such as at the vent gases from pulp washing systems, the noncondensable gases from digesters and multiple-effect evaporators, and the vent gases from condensate strippers. Incineration in the recovery furnace or power boiler is the most likely control alternative for this facility since no significant fuel penalties will result. Condensers may be required to reduce moisture content before burning, especially if the moist washer gases are burned in the same furnace.

The use of molecular oxygen instead of air in oxidation systems is considered an alternative control system. At least two mills in the United States now oxidize black liquor by pumping oxygen directly into the black liquor lines. There are no vent gases from this closed system. The economic feasibility of such a system will depend largely on the price and availability of oxygen.

Based on data from incinerator systems burning similar gases, TRS combustion residuals from control of BLO vent gases are estimated to be less than 5 ppm (0.01 lb/T ADP). Enclosed oxygen systems have no TRS emissions.

4.2.4 Recovery Furnace System

The TRS emissions from the recovery furnace are controlled by maintaining proper process conditions. The most important operating variables whose control are required for minimum TRS emissions are black liquor firing rate, available oxygen for combustion, air-to-solids ratio, and the ratio of primary to secondary and tertiary air.[17]

There are two general process designs that reduce TRS emissions that normally result from a direct-contact evaporator: the direct-contact system with black liquor oxidation and the indirect-contact system. In the direct-contact system, final concentration is accomplished by bringing the recovery furnace combustion gases into direct contact with the black liquor. The reactions between the combustion gases and black liquor that normally generate hydrogen sulfide, however, are inhibited by oxidizing the black liquor before it enters the direct-contact evaporator. In the indirect-contact system, direct contact between furnace gases and black liquor is eliminated, and hydrogen sulfide is prevented from forming.

Variations of both furnace systems are found in practice. In the direct contact system, the black liquor is sometimes oxidized before being concentrated in the multiple-effect evaporators (weak black liquor oxidation), sometimes following evaporation (strong black liquor oxidation), and sometimes both. Air is the normal oxidizing agent, but molecular oxygen is also used when a supply is on hand. Air sparging reactors are the most common units, but packed towers and bubble tray towers are also found. The various indirect contact systems are called Direct Fired (Babcock and Wilcox Co.), Large Economizer, Laminaire Heater, and Air Contact Evaporation (last three by Combustion Engineering Inc.).

TRS emissions from direct contact systems depend on the design and operation of the recovery furnace and the oxidation system. A survey of 32 recovery furnace systems where black liquor oxidation was not used shows TRS emissions ranging from 35 to 1300 ppm (1.5 to 62 lb/T ADP) with a median of 5.9 lb/T ADP.[18] A survey of 17 units utilizing black liquor oxidation indicates a broad TRS emission range of 0.2 to 25.9 lb/T ADP with a median value of 3.7 lb/T ADP.[19] As mentioned previously, black liquor oxidation is not effective in reducing TRS emissions from the furnace proper. The effectiveness of black liquor oxidation on preventing TRS emissions resulting from the direct contact evaporator is dependent on how the oxidation system is designed and operated. TRS emissions from indirect-contact systems are usually confined to a narrow range of about 0.03 to 0.3 lb/T ADP (1 to 11 ppm).

One control system that has recently been demonstrated on pilot plant scale and is currently being applied to a full-scale furnace removes TRS from the recovery furnace gas stream and reportedly results in emission levels comparable with black liquor oxidation - direct-contact evaporator furnace systems and the indirect-contact furnace system. This system utilizes a low pressure drop cross flow caustic scrubber with activated carbon as a catalyst. EPA has not tested this control system because it has only recently been developed and applied. This may represent another viable alternate for controlling TRS from the recovery furnace.

4.2.5 Smelt Dissolving Tank

There are no special TRS control devices for smelt dissolving tanks. TRS emissions are governed by process conditions, and the principal option available is the choice of water. Clean water, low in dissolved sulfides, is preferable, although low emissions are possible with nearly any process stream.[20]

TRS emissions from dissolving tanks are normally low and average about 0.01 g/kg ADP (0.02 lb/T ADP).[21]

4.2.6 Lime Kiln

TRS emissions from lime kilns can be emitted from two sources within the installation: the lime kiln itself and the particulate control device (e.g. scrubbers). The TRS emissions from the lime kiln installation are controlled by maintaining proper process conditions. The most important parameters that were identified in a recent study by the NCASI[22] are the temperature at the cold end point of exhaust discharge, the oxygen content of the gases leaving the kiln, the sulfide content of the lime mud fed to the kiln, and the pH and sulfide content of the scrubbing water.

Further reduction of the TRS concentration in the emissions from this facility can be accomplished by the addition of a caustic solution to the scrubbing water. Maintenance of the process controls is also required with this technique. The effectiveness of caustic scrubbing is limited to absorbing only hydrogen sulfide and methyl mercaptan. TRS emissions from lime kilns, however, are principally hydrogen sulfide; therefore, the combination of process control and caustic scrubbing can be very effective in the control of TRS.

TRS emissions from lime kilns range from about 0.02 to 4.0 lb/T ADP, with an average of about 0.8 lb/T ADP.[23]

4.2.7 Condensate Strippers

In at least three United States mills, dissolved sulfides and other volatile compounds are stripped from the digester and evaporator condensates prior to discharge. At two mills, the gases discharged from the stripper column are burned in a lime kiln. One stripper uses air; the other uses steam as the stripping agent. The other mill burns the gases from an air stripper in a separate incinerator. There are no alternative control techniques for the off-gases presently practiced.

TRS emissions in the stripper gases following incineration are estimated to be less than 0.01 lb/T ADP (5 ppm).

4.3 ALTERNATIVE CONTROL SYSTEMS

The alternative control systems that are considered the best combinations of the control techniques previously discussed are presented in this section. The analyses of environmental effects in chapter 7 and of economic impact in chapter 8 will examine the impacts associated with the alternative emission control systems. Since there are multiple facilities and several alternatives for control of many of the processes, not all the possible systems are presented. Only the systems that are judged to be representative of the best systems, considering costs, are considered. Alternative standards are not discussed in this section. The rationale for the selection of the best system of emission reduction considering costs is presented in chapter 9.

Alternative number 1 represents a control system based on the average level of state standards that would apply to a new kraft pulp mill in the absence of new source performance standards. A summary of the present state control standards specific to kraft pulp mills is presented in Table 4.4. The control techniques required to meet these levels are:

- Recovery furnace - 99.0% ESP for particulate control plus a single stage of black liquor oxidation for TRS control.
- Smelt Dissolving Tank - Demister
- Lime Kiln - 15" venturi scrubber
- Digester System - Incineration
- Multiple Effect Evaporators - Incineration

TABLE 4.4. Summary of Present State Control Standards for Kraft Pulp Mills

Affected Facility	Number of States With Existing Standards	Typical Control Standard	Most Stringent Standard
Particulates			
Recovery furnace	12	4 lb/T ADP	2.75 lb/T ADP
Smelt dissolving tank	10	0.5 lb/T ADP	0.5 lb/T ADP
Lime kiln	12	1.0 lb/T ADP	0.5 lb/T ADP
TRS			
Recovery furnace	12	17.5 ppm	1 ppm
Smelt dissolving tank	None	-	-
Lime kiln	3	40 ppm	10 ppm
Digester system	5	Incineration of non-combustibles	-
Multiple-effect evaporator system	5	Incineration of non-combustibles	-
Black liquor oxidation tank	None	-	-
Brown stock washers	1	Incineration of gases	-
Condensate strippers	1	Incineration of gases	-

- Brown Stock Washer Systems - No control
- Black Liquor Oxidation System - No control
- Condensate Stripper System - Incineration

Alternative number 2 consists of the following control techniques:

Recovery furnace - 99.9% ESP plus process control;
black liquor oxidation or non-contact evaporation

Smelt Dissolving Tank - Scrubber plus use of clean
water (process control)

Lime Kiln - 30-inch venturi scrubber with caustic addition
to scrubber water plus process controls

Digester Systems - Incineration

Multiple-Effect Evaporators - Incineration

Brown Stock Washers - Incineration

Black Liquor Oxidation System - Incineration

Condensate Stripper System - Incineration

Alternative number 3 is identical to system 2 except that caustic is not added to the scrubber water on the lime kiln control system. TRS emissions from the lime kiln are increased as a result of this change.

Alternative number 4 is identical to system number 3 except that the venturi scrubber used for control of particulate emissions from the lime kiln is replaced with a high efficiency electrostatic precipitator. TRS emissions from the kiln are controlled by the use of good process control.

Alternative number 5 is a composite system based on alternatives 2 and 4. Both a caustic scrubber and an ESP are used for the simultaneous control of TRS and particulate emissions from the lime kiln. Although this system has not been demonstrated, it is assumed that it is technically possible to apply.

References for Chapter 4

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18. Reference 1, Table 14.

19. Reference 1, Table 15.

20. Reference 1, Table 25.

21. Reference 1, Table 25.

22. NCASI, Suggested Procedures for the Conduct of Lime Kiln Studies to Define Emissions of Reduced Sulfur Through Control of Kiln and Scrubber Operating Variables, NCASI Special Report No. 71-01, January 1971.

23. Reference 1, Table A-5.

24. Engelbrecht, H.L., "New Precipitator Design Licks Recovery Emission Problems," TAPPI, 55(a), September 1975.

25. Air Pollution Emission Test 74-KPM-15 (Recovery Furnace K), June 1974.

5. MODIFICATION AND RECONSTRUCTION

The proposed standards apply to all affected facilities constructed or modified after the date of proposal of the proposed standards. Provisions applying to modification and reconstruction were originally published in the Federal Register on December 23, 1971. Clarifying amendments were proposed in the Federal Register on October 15, 1974 (39 FR 36946), and final regulations were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Modification is defined as "any physical change in, or change in the method of operation of, an existing facility which increases the amount of any air pollutant (to which a standard applies) emitted into the atmosphere by that facility or which results in the emission of any air pollutant (to which a standard applies) into the atmosphere not previously emitted." Reconstruction occurs when components of an existing facility are replaced to such an extent that:

(1) The fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and

(2) It is technologically and economically feasible to meet the applicable standards.

There are certain circumstances under which an increase in emissions does not result in a modification. If a capital expenditure, that is less than the most recent annual asset guideline repair allowance published by the Internal Revenue Service (Publication 534), is made to increase capacity at an existing facility and also results in an increase in emissions to the atmosphere of a regulated pollutant, a modification is not considered to have occurred. Other cases under which an increase in emissions does not constitute a modification occurs when the increase is caused by an increase in capacity throughput or a change in the type of fuel being used when these changes do not involve a change in the original design of the facility. Additionally, if an increase in emissions has occurred which could be considered a modification, the amount of increased emissions, in Kg per hour, may be traded off by reducing emissions of the same pollutant from another facility within the same kraft pulp mill, as long as it can be shown that the total emissions of that pollutant from the mill has not increased. This is referred to as the "bubble concept".

The purpose of this chapter is to identify potential modifications and reconstructions of affected facilities, and any exemptions or special allowances covering changes in existing facilities that should be considered. Exemptions from the regulations may be based on availability of technology and economic considerations;

The following physical changes and changes in the method of operation of kraft pulp mills were considered:

(1) Conversion of a direct-contact furnace system to an indirect-contact system;

(2) Conversion of a lime kiln from burning natural gas to burning oil;

(3) Adding an additional stage of washers to an existing brown stock washer system.

5.1 CONVERSION OF A DIRECT-CONTACT FURNACE SYSTEM TO A NON-CONTACT SYSTEM

Occasionally, an existing recovery furnace will be changed by replacing the direct-contact evaporator with a steam-heated indirect-contact evaporator. The main purpose for this change is to reduce TRS emissions from the recovery furnace system. The new indirect-contact evaporator, however, becomes a part of the multiple-effect evaporator system, causing a possible increase in TRS mass emissions from this affected facility. Since the conversion of a direct-contact furnace system to a non-contact system will reduce TRS emissions, the bubble concept may be applied to account for the possible increased TRS emissions from the evaporators. If the original system employed black liquor oxidation, it is possible that this step would be removed from operation. Should this occur, a further reduction in TRS emissions would take place. This reduction could be applied to the bubble concept in the trade off of emissions.

This change would also possibly result in an increase of particulate emissions from the furnace. Without the direct-contact evaporator, inlet particulate loadings to the precipitator will increase. To account for this increase in emissions, the collection efficiency of the existing ESP must be upgraded to meet the requirements of the proposed new source performance standards or the emissions must be traded off under the bubble concept by a reduction of particulate emissions elsewhere in the mill. The costs associated with upgrading the precipitator have been analyzed and are presented in Table 8-28 of the Economic Impact chapter. The annual costs for this conversion is about 0.41 dollars per ton for both a 500 ton-per-day and a 1000 ton-per day mill.

5.2 CONVERSION OF A LIME KILN FROM BURNING NATURAL GAS TO BURNING OIL

An existing lime kiln that burns natural gas may be converted to burn fuel oil. This change in fuel would cause an increase in particulate emissions from the facility. If the kiln was not originally designed to burn oil as an alternative fuel, the change in fuels would constitute a modification.

The maximum impact would occur if the entire existing scrubber system were replaced to control the increased particulate emissions. Additional TRS control would not be required in this case; therefore, there would be no need for the addition of caustic to the scrubbing solution. The cost requirements for this modification are summarized in Table 8-29. The annual costs for the new control system range from 0.20 dollars per ton for a 1000-ton-per-day mill to 0.33 dollars per ton for a 250-ton-per-day mill.

5.3 ADDING AN ADDITIONAL STAGE OF WASHERS TO AN EXISTING BROWN STOCK WASHER SYSTEM

An additional stage of brown stock washer may be added to an existing line of washers in order to improve washing efficiency. It is expected that this change will usually take the form of adding a fourth stage. Emission of TRS may increase as a result of this change, subjecting this facility to the provisions of §60.14.

The costs for this modification were analyzed for two cases: (1) major retrofit of ventilating system plus incineration of TRS emissions in an existing recovery furnace, and (2) major retrofit of ventilating system plus incineration of the TRS emissions in a separate incineration system. The cost estimates for these two cases are summarized in **Table** 8-27 for 250, 500, and 1000 ton per day mills. The worst case, that involving use of a separate incinerator, requires an annual cost of as high as 3.84 dollars per ton for a 250-ton-per-day mill.

6. EMISSION DATA TO SUBSTANTIATE THE PROPOSED STANDARDS

Emission data presented in this section are the results of tests conducted by EPA at 12 kraft pulp mills. These data represent 11 TRS tests and 19 particulate tests performed on the various facilities affected by the proposed standards. Eight emission tests were performed on seven recovery furnaces for particulate or TRS; five smelt dissolving tanks were tested; eight tests were performed on seven lime kilns; and four tests were run on four different miscellaneous sources for TRS. Opacity readings were taken during particulate tests on four stacks at three recovery furnaces, during tests on three smelt dissolving tank stacks, and during two tests on one lime kiln. The visible emissions readings on the recovery furnace stacks totalled 5514 minutes (919 six-minute averages). The total for the smelt dissolving tank is 206 minutes and 15 seconds; the total for the lime kiln is 682 minutes and 30 seconds. The results of these emissions tests are used to substantiate the proposed standards. Additional data that were obtained from various kraft mills, state air pollution control agencies, and other sources are also presented where pertinent.

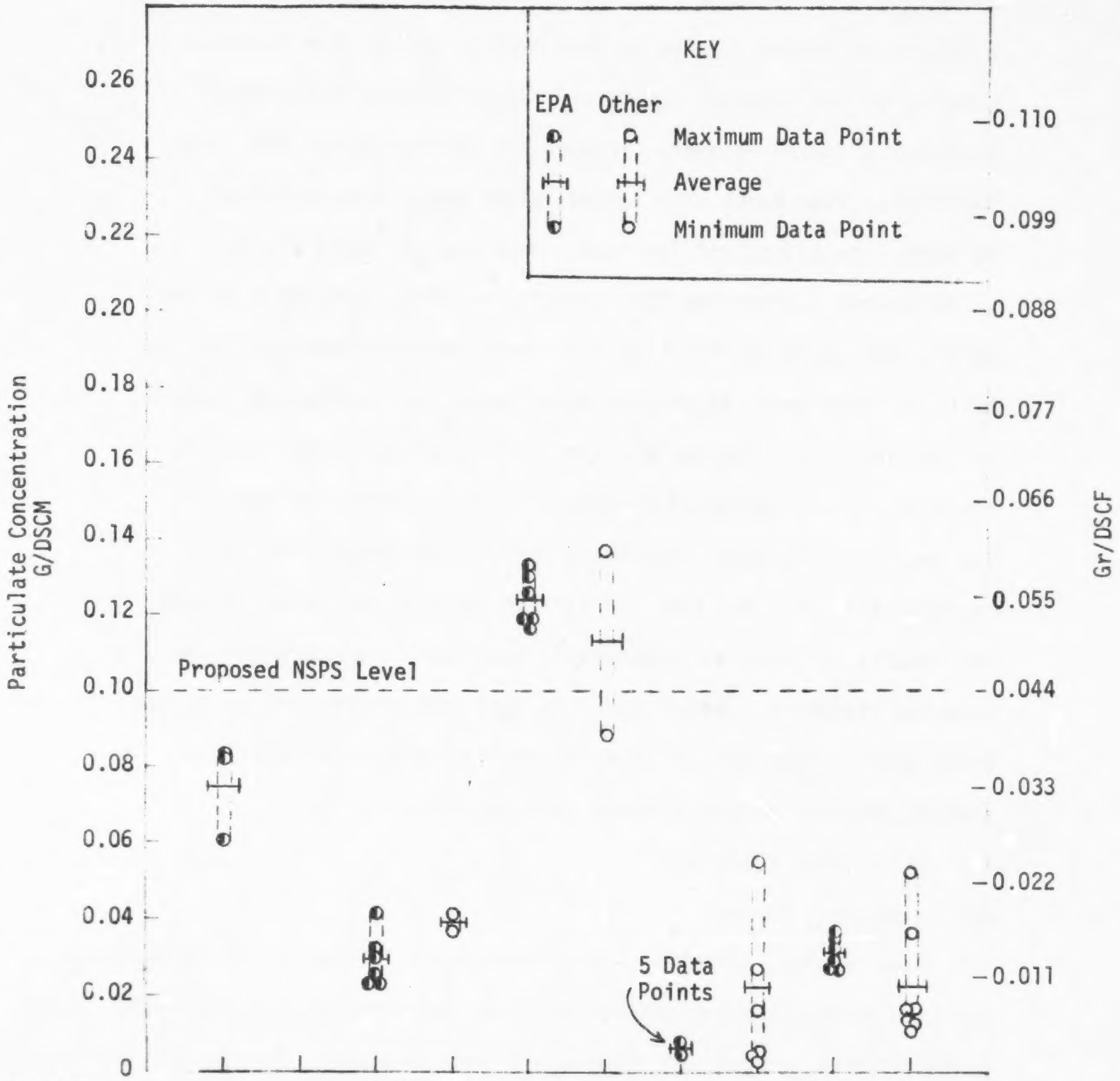
6.1 PARTICULATE EMISSIONS

6.1.1 Recovery Furnace

Five recovery furnaces were tested by EPA. Three of the furnaces had direct-contact evaporators; the other two furnaces were indirect-contact (no direct-contact evaporator) type furnaces. The particulate emissions for the furnaces tested are shown in Figure 6-1. Data

Figure 6-1

Particulate Concentrations in Control Systems Exhaust from Kraft Recovery Furnaces



FURNACE	D	J'1	J'2	J"1	J"2	K1	K2	L1	L2
Furnace Type	DC	IC	IC	IC	IC	IC	IC	DC	DC
Control Equipment	P	P	P	P	P	P	P	P	P
Test Report Reference	3,4	6	-	6	-	7	-	8	-

IC - Indirect Contact
DC - Direct Contact
P - Electrostatic Precipitato

obtained from the operators of mills with several of the furnaces tested by EPA are also presented in Figure 6-1 for comparison purposes. Visible emission data for the furnaces tested are presented in Tables 6-1 to 6-4.

In addition, EPA contacted several vendors and operators in response to comments on long-term precipitator performance on recovery furnaces. The conclusions of this investigation, discussed in detail in section 4.1.1, is that with proper design and maintenance a well operated precipitator can control particulate emissions from recovery furnaces to below the level of the proposed standard of 0.10 g/dscm.

Furnace D

Furnace D, which uses a direct-contact evaporator, is designed for an equivalent pulp production rate of 602 tons per day. Furnace D was operating at 90 to 95 percent of design capacity during the EPA testing. This furnace was tested twice by EPA,[3,4] in tests conducted about one year apart. Three runs were performed during each test. The particulate emissions from this facility are controlled by a wet-bottom electrostatic precipitator. Information supplied by the operator indicate that this electrostatic precipitator has an operating collection efficiency of 99.5 percent and a collection surface area-to-gas volume ratio of 346 (sq. ft/1000 acfm). The first set of EPA tests were inconclusive because results indicated abnormal conditions were existing during the test due to either a control device or furnace malfunction or to improper testing. This conclusion is supported by company data obtained over a 17-month period which indicated an average emission rate of 0.128 g/dscm (0.056 gr/dscf). During the second set of EPA tests, D on Figure 6-1, the emissions ranged from 0.061 to 0.083 and averaged 0.075 g/dscm (0.033 gr/dscf), corrected to 8 volume percent oxygen. Oxygen levels in the exhaust gases during these tests ranged between 9.8 and 10.6 percent. Visible emission data, Table 6-1, were also obtained during the second set of tests. The span of the six-minute average opacity readings was 0 to 29.2 with an average of about 16.3 percent.

Furnace J

Furnace J, which does not have a direct-contact evaporator, is designed for an equivalent pulp production rate of 1100 tons per day. This furnace was tested by EPA while it was operating at design capacity. The particulate emissions are controlled by a dry-bottom electrostatic precipitator which has a design collection efficiency of 99.8 percent and has a collection surface area-to-gas volume ratio of 383 sq. ft/1000 acfm. The precipitator has two separate identical chambers in parallel; each chamber has five electrical fields. The exhaust gases from each chamber exit through separate stacks. Both stacks were simultaneously tested for a total of six test runs on each stack.[6]

The emissions from the one half (J') ranged from 0.023 to 0.041 g/dscm with an average of 0.029 g/dscm (0.013 gr/dscf). Oxygen levels in the exhaust were less than 8 percent by volume. The emissions from the other half (J") ranged from 0.117 to 0.133 g/dscm and averaged 0.124 g/dscm (0.054 gr/dscf).

Table 6-1

Summary of Visible Emissions for Recovery Furnace D

Date: Nov. 1-2, 1973

Type of Plant: Kraft Pulp Mill

Type of Discharge: Stack

Location of Discharge: Recovery Furnace

Height of Point of Discharge: 250 ft.

Description of Background:

Description of Sky:

Wind Direction: Not Available

Color of Plume:

Interference of Steam Plume:

Duration of Observation: 11/1 - 19 min., 15 sec.
11/2 - 22 min., 15 sec.
41 min., 30 sec.

Distance from Observer to Discharge Point: 30 ft.

Height of Observation Point: 220 ft.

Direction of Observer from Discharge Point:

Wind Velocity: Not Available mi/hr

Detached Plume:

Summary of Data: (Normalized to a 3.0 m stack diameter):

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Particulate Concentration g/dscm(gr/dscf)
1	4	14.2 - 29.2	24.1	0.07 (0.031)
2	3	0 - 11.1	6.0	0.05 (0.021)

Visible emission data were also recorded during the particulate tests and indicate that the average opacity from precipitator J', Table 6.2, and J", Table 6.3, was less than 8 and 45 percent, respectively.

Data J'2 and J"2 (two tests) obtained from the operator indicate that the particulate emissions from precipitator J' and J" range from 0.037 to 0.041 g/dscm and from 0.087 to 0.137 g/dscm, respectively.

Since the precipitators (J' and J") are physically separated, have the same design and operating parameters, and handle approximately half of the exhaust flow from the furnace, the only difference between the two precipitators was the maintenance received. The turning vanes and air distribution plates on precipitator J' were cleaned one month prior to the EPA tests. The air distribution plates on precipitator J" were cleaned about three months prior to EPA's testing but the turning vanes had not been cleaned since the precipitator went into operation (about 17 months prior to EPA tests). The operator felt that the reason for the poorer collection efficiency on the one half (J") was due to the turning vanes and air distribution plates being caked which resulted in improper air patterns through the precipitator. The manufacturer also stated that improper air distribution through a precipitator resulting from buildup on the turning vanes can reduce the collection efficiency of the precipitator.[26] At the time of the test, there were no cleaning mechanisms such as rappers on these turning vanes to keep

Table 6-2

Summary of Visible Emissions for Recovery Furnace J'

Date: Jan. 22-25, 1974

Type of Plant: Kraft Pulp Mill

Type of Discharge: Stack

Distance from Observer to Discharge Point: 30 ft.

Location of Discharge: Recovery Furnace #5

Height of Observation Point: 240 ft.

Height of Point of Discharge: 250 ft.

Direction of Observer from Discharge Point: S.W.

Description of Background: Sky and frequent plumes from other stacks

Description of Sky: Clear to partly cloudy

Wind Direction: S-SE

Wind Velocity: 0-15 mi/hr

Color of Plume: White

Detached Plume: No

Interference of Steam Plume: No

Duration of Observation: 15 hrs., 58 minutes

Summary of Data: (Normalized to a 3.0 m stack diameter):

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Particulate Concentration g/dscm(gr/dscf)
1A	27	0.7-8.2	2.2	0.02 (0.011)
B	27	1.0-15.2	7.6	
2A	20	0-1.3	0.5	0.04 (0.018)
B	28	0-2.0	0.5	
3A	20	0-8.2	2.5	0.03 (0.013)
B	-	no readings taken	-	
4A	27	0-0	0	0.02 (0.010)
B	20	0.3	0	
5A	20	0-10.0	4.1	0.02 (0.010)
B	20	0-3.2	0.8	
6A	17	0-0	0	0.03 (0.014)
B	20	0.5	0.5	

Table 6-3

Summary of Visible Emissions for Recovery Furnace J"

Date: Jan. 22-25, 1974
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Distance from Observer to Discharge Point: 30 ft.
Location of Discharge: Recovery Furnace #5
Height of Observation Point: 240 ft.
Height of Point of Discharge: 250 ft.
Direction of Observer from Discharge Point: S.W.
Description of Background: Sky and frequent plumes from other stacks

Description of Sky: Clear to partly cloudy

Wind Direction: S-SE
Wind Velocity: 0-15 mi/hr
Color of Plume: White
Detached Plume: No
Interference of Steam Plume: No
Duration of Observation: 14 hrs., 18 minutes

Summary of Data (Normalized to a 3.0 m stack diameter)

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Particulate Concentration g/dscm (gr/dscf)
1A	27	20.3-40.5	28.4	0.13 (0.058)
B	27	15.8-39.0	30.8	
2A	20	18.0-50.0	38.8	0.12 (0.055)
B	28	29.4-49.4	40.3	
3A	18	15.5-42.2	30.5	0.12 (0.053)
B	18	12.4-30.8	22.1	
4A	15	25.7-46.8	40.0	0.13 (0.057)
B	20	20.1-42.9	34.2	
5A	14	23.8-46.4	36.9	0.12 (0.052)
B	19	23.8-41.0	34.2	
6A	18	40.6-51.5	45.4	0.12 (0.053)
B	20	26.6-48.6	35.1	

them clean. The manufacturer stated that rappers could be installed to keep the turning vanes free of buildup. A certain amount of engineering work would be necessary to determine the number and location of the rappers in order to keep the turning vanes cleaned during continuous operation.[26]

Furnace K

Furnace K, which does not have a direct-contact evaporator, is designed for an equivalent pulp production rate of 863 tons per day. The particulate emissions from Furnace K are controlled by a dry-bottom electrostatic precipitator with a design efficiency of 99.5 percent and a surface area-to-volume ratio of 441 (sq. ft/1000 acfm), but during the testing by EPA the ratio was 570 (sq. ft/1000 acfm) due to the furnace operating at 74 percent of design capacity. This ratio of 570 is much higher than the normal surface-to-volume ratio encountered in this industry. Five test runs were conducted on Furnace K by EPA.[7] The particulate emissions ranged from 0.006 to 0.008 g/dscm with an average of 0.007 g/dscm (0.0031 gr/dscf), corrected to eight volume percent oxygen. Oxygen levels were about 10 percent during the EPA testing.

Monthly data (K2) obtained over a period of seven months from the state agency show that the particulate emissions range from 0.003 to 0.055 g/dscm.

Weather conditions existing during the EPA tests did not permit opacity observations on Furnace K.

Furnace L

Furnace L is designed for an equivalent pulp production rate of 550 tons per day. The furnace has a direct-contact evaporator.

The particulate emissions from Furnace L are controlled by an electrostatic precipitator with a design collection efficiency of 99.5 percent. This precipitator has a design collection surface area-to-gas volume ratio of 402 (sq. ft/1000 acfm). Six test runs were performed on this furnace by EPA.[8] Furnace L was operating at 16 percent above design capacity during the testing. The emissions (L1) from these tests ranged between 0.028 and 0.037 g/dscm and averaged 0.032 g/dscm (0.014 gr/dscf).

Data (L2) obtained over a period of two months (7 tests) from the company show that the particulate emissions ranged between 0.011 and 0.053 g/dscm.

Visible emission measurements, Table 6.4, made during the EPA tests indicate that the average opacity of the plume from Furnace L is less than 6 percent. The six-minute averages ranged from 4.4 to 8.7 percent opacity. The stack gas opacity peaked at regular intervals during the tests. These small increases in opacity were observed to coincide with cleaning of the induced draft fan. This fan is blown with steam at approximately twelve-minute intervals.

Furnace I

Furnace I was also tested by EPA[5] but the data are not presented in Figure 6.1. This furnace has a direct-contact evaporator and is designed for an equivalent pulp production rate of 900 tons per day. During the testing, the furnace was operating at about 78 percent of design capacity. The particulate emissions are controlled by an electrostatic precipitator with design collection efficiency of 98.8 percent.

Table 6-4

Summary of Visible Emissions for Recovery Furnace L

Date: May 7-10, 13, 14, 1974
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Distance from Observer to Discharge Point: 850 ft.
Location of Discharge: Recovery Furnace #2
Height of Observation Point: Ground
Height of Point of Discharge: 220 ft.
Direction of Observer from Discharge Point: East
Description of Background: Sky-Clouds

Description of Sky: Sunny, partly cloudy

Wind Direction: Variable
Wind Velocity: 0-15 mi/hr
Color of Plume: White
Detached Plume:
Interference of Steam Plume:
Duration of Observation: 23 hrs., 51 minutes

Summary of Data

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Particulate Concentration g/dscm (gr/dscf)
1A	36	4.4-6.8	5.3	0.03 (0.014)
B	39	4.4-8.7	5.1	
2A	38	4.4-6.3	4.9	0.03 (0.012)
B	36	4.4-5.5	4.7	
3A	31	4.4-6.5	5.0	0.03 (0.013)
B	16	4.4-6.5	4.7	
4A	38	4.4-6.3	4.9	0.03 (0.012)
B	30	4.4-6.3	4.7	
5A	43	4.4-6.3	4.9	0.04 (0.016)
B	30	4.4-6.3	4.8	
6A	45	4.4-6.8	5.0	0.03 (0.015)
B	40	4.4-6.3	4.9	

The emissions from Furnace I ranged from 0.215 to 0.295 g/dscm and averaged 0.262 g/dscm (0.115 gr/dscf) over three test runs. No visible emission readings were taken during this test. Oxygen levels in the exhaust during the testing were about 7 percent.

All three test runs were conducted during sootblowing. Sootblowing on this furnace is not continuous as is commonly practiced but is performed once a shift or less often. Each soot blowing cycle takes about three hours which is the approximate duration the sampling probe was in the stack. Therefore, this data represents a maximum or peak emission. The other four furnaces tested, however, have continuous, sequentially repeated sootblowing.

Visible Emissions

A total of 919 six-minute averages were taken during the particulate tests on furnaces D, J', J", and L. The particulate concentration during each test run was plotted versus the six-minute average opacities recorded during the same period. By plotting a least squares fit line on these data points, a correlation between particulate concentration in g/dscm and the plume opacity can be made. The 95 percent confidence limit, based on the standard deviations of each test run, was also determined and plotted along with the average. The results of this study are shown in Figure 6-2. All opacity data were normalized to a 3.0 meter stack diameter for these calculations.

6.1.2 Smelt Dissolving Tanks

Four smelt dissolving tanks were tested by EPA. The data from these tests are presented in Figure 6-3. Monthly data obtained from

Figure 6-2. Percent Opacity vs. Particulate Concentration for Recovery Furnace Emissions (All data normalized to a 3.0 meter stack diameter)

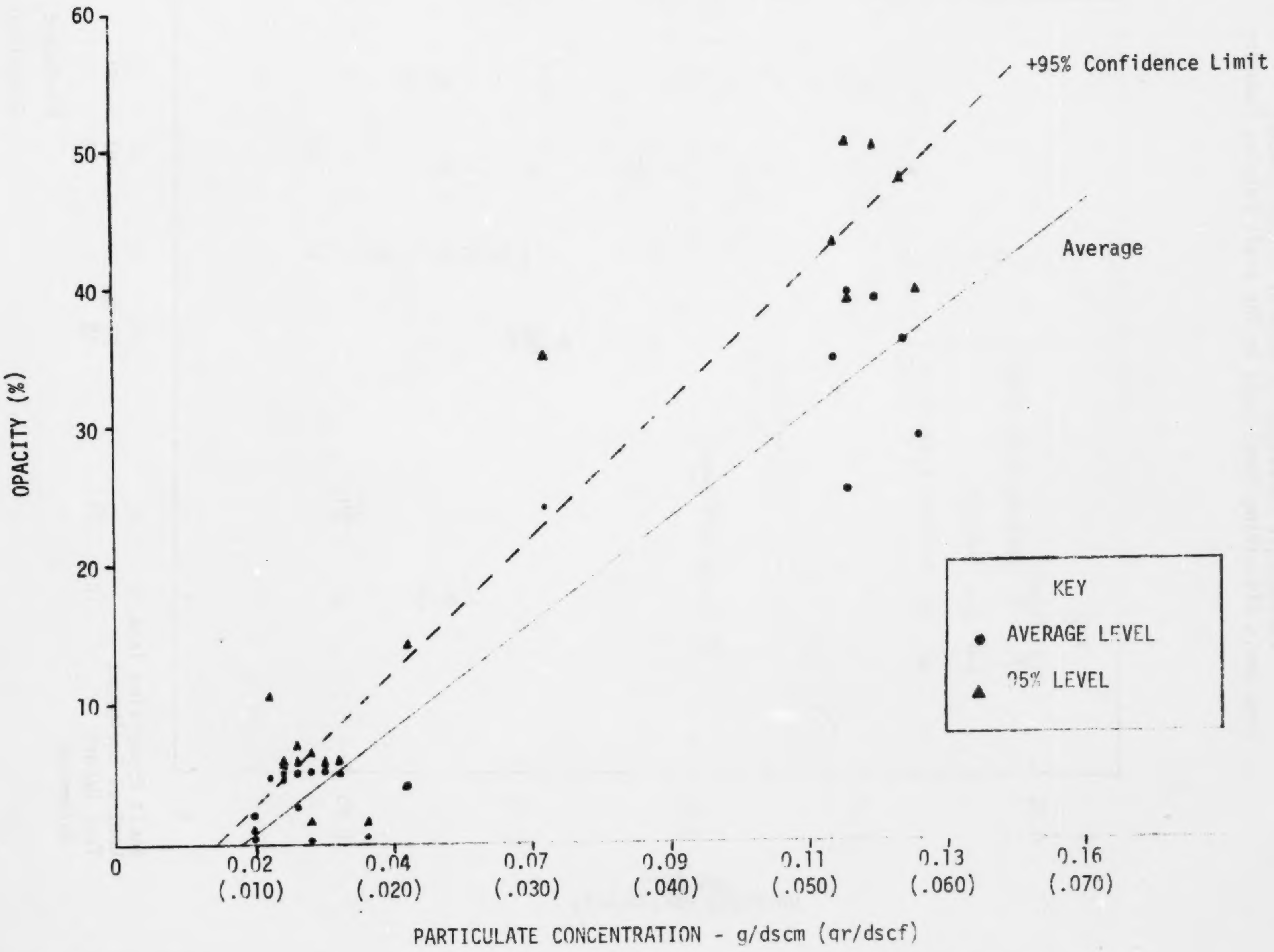
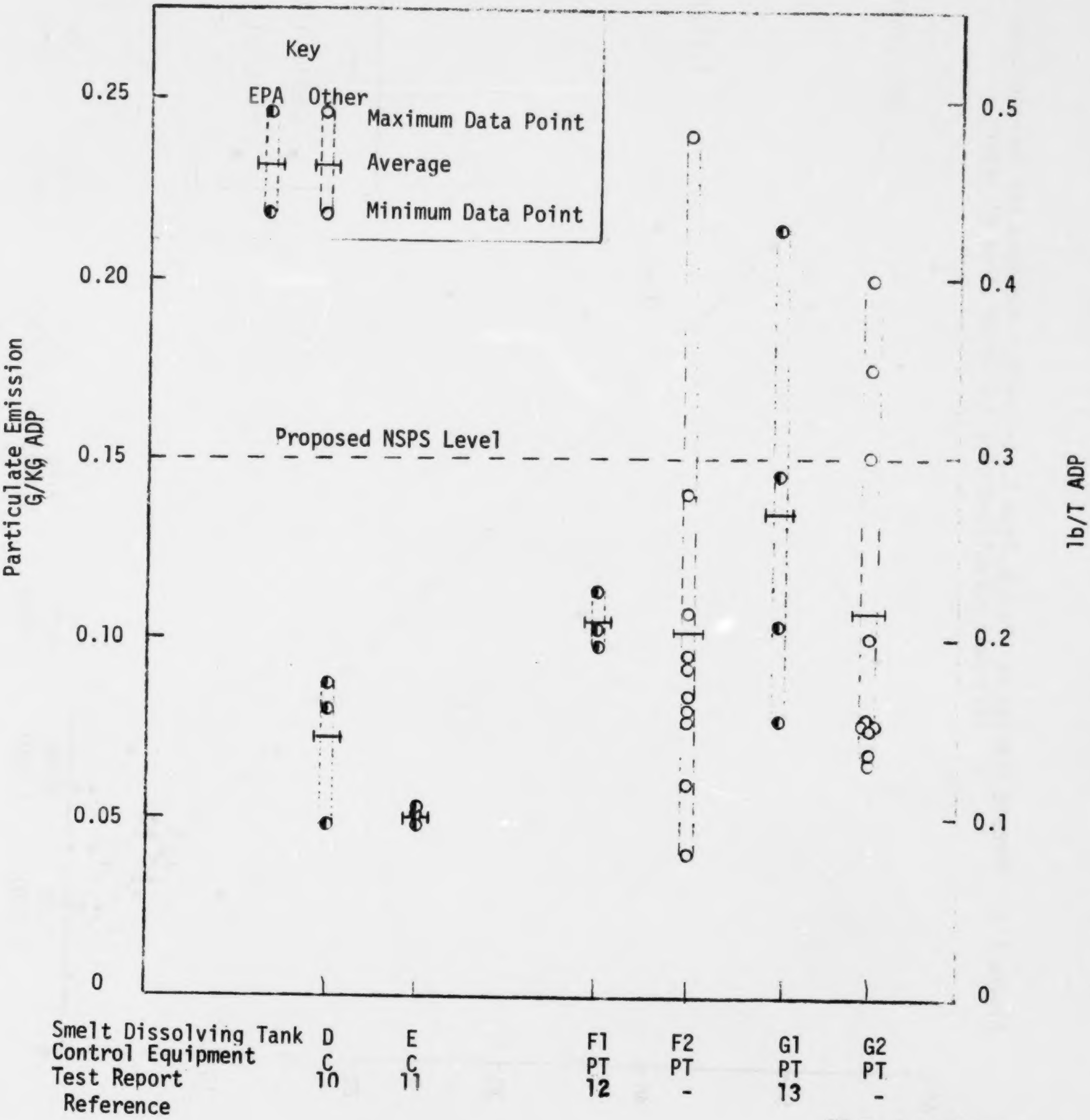


Figure 6-3

Particulate Emissions in Control System Exhaust
From Smelt Dissolving Tanks Used In The Kraft Pulping Industry



PT-Packed Tower

C-Cyclonic Scrubber

a state agency on two of the smelt tanks are also presented. Visible emissions data for the smelt dissolving tanks tested are shown in Tables 6-5 to 6-7. Visible emissions are normally difficult to obtain from smelt dissolving tanks due to the interfering steam usually present in the plume. The data that were taken are considered to be questionable and do not constitute a sufficient data base upon which to base an opacity standard.

Smelt Dissolving Tank D

Particulate emissions from smelt dissolving tank D are controlled by a wet fan scrubber. Demister pads are also installed to aid the scrubber. Three test runs were performed by EPA on this facility.[10] The measured emissions ranged from 0.048 to 0.088 g/kg ADP and averaged 0.072 g/kg ADP (0.143 lb/T ADP).

Visible emission data, Table 6.5, obtained during the EPA test indicate that the opacity of the residual plume from this smelt tank is zero percent. Smelt Tank D associated recovery furnace operates at an equivalent pulp production rate of 570 tons per day.

Smelt Dissolving Tank E

The particulate emissions from smelt dissolving tank E are controlled by a wet scrubber which is basically a wet fan cyclone. The particulate emissions during the EPA test runs ranged from 0.048 to 0.053 g/kg ADP and averaged 0.05 g/kg ADP (0.1 lb/T ADP).[11]

It was not possible to obtain meaningful data on the visible emissions from this smelt dissolving tank since the plume mixed with plumes from other facilities in the mill.

The associated recovery furnace at this mill was operating at an equivalent pulp production rate of 770 tons per day during the test.

Table 6-5

Summary of Visible Emissions for Smelt Dissolving Tank D

Date: Oct. 1-2, 1973
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Location of Discharge: Smelt Dissolving Tank
Height of Point of Discharge: 250 ft.
Description of Background: Clouds or Blue Sky

Distance from Observer to Discharge Point: 40 ft.
Height of Observation Point: 240 ft.
Direction of Observer from Discharge Point: East

Description of Sky: Clear to partly cloudy

Wind Direction: SW
Color of Plume: White
Interference of Steam Plume: Yes
Duration of Observation: 74 min., 45 sec.

Wind Velocity: 10 mi/hr
Detached Plume: No

Summary of Data:

Observation	6-Minute Average Opacity (%)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0

Smelt Dissolving Tank F

The particulate emissions from smelt dissolving tank F are controlled by a packed scrubber tower. Three test runs on this facility were performed by EPA.[12] The emissions (F1) ranged from 0.098 to 0.114 g/kg ADP and averaged 0.105 g/kg ADP (0.209 lb/T ADP).

Visible emission data, Table 6-6, obtained during the EPA tests indicate that the opacity of the residual plume from smelt tank F is less than 10 percent.

Data (F2) obtained from the state agency over a period of ten months show that the particulate emissions ranged from 0.040 to 0.240 g/kg ADP and averaged 0.101 g/kg ADP (0.202 lb/T ADP). Smelt tank F associated recovery furnace operates at an equivalent pulp production rate of 450 tons per day.

Smelt Dissolving Tank G

Particulate emissions from smelt dissolving tank G are also controlled by a packed scrubber tower. Four test runs were conducted on smelt tank G by EPA.[13] The emissions (G1) during these tests ranged from 0.078 to 0.215 g/kg ADP and averaged 0.135 g/kg ADP (0.27 lb/T ADP).

Visible emissions data, Table 6-7, obtained during these tests show that the opacity of the residual plume averages below 10 percent.

Data (G2) obtained from the state agency over a period of ten months ranged from 0.065 to 0.200 g/kg ADP and averaged 0.106 g/kg ADP (0.212 lb/T ADP).

Table 6-6

Summary of Visible Emissions for Smelt Dissolving Tank F

Date: Oct. 9, 1973
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Location of Discharge: Smelt Dissolving Tank
Height of Point of Discharge: 125 ft.
Description of Background:

Distance from Observer to Discharge Point: 750 ft.
Height of Observation Point: 125 ft.
Direction of Observer from Discharge Point: South

Description of Sky: Hazy and partly cloudy

Wind Direction: West
Color of Plume: White
Interference of Steam Plume: yes
Duration of Observation: 56 min., 30 sec.

Wind Velocity: 5 mi/hr
Detached Plume: No

Summary of Data:

Observation	6-Minute Average Opacity (%)
1	1.9
2	2.3
3	1.2
4	0.8
5	1.0
6	0.6
7	0.0
8	-
9	0.4
10	0.0

Table 6-7

Summary of Visible Emissions for Smelt Dissolving Tank G

Date: Oct. 16 & 18, 1973	
Type of Plant: Kraft Pulp Mill	
Type of Discharge: Stack	Distance from Observer to Discharge Point: 50 ft.
Location of Discharge: Smelt Dissolving Tank #3	Height of Observation Point: 140 ft.
Height of Point of Discharge: 150 ft.	Direction of Observer from Discharge Point: W-SW
Description of Background: Hazy sky	
Description of Sky: Sunny, partly cloudy	
Wind Direction: West	Wind Velocity: 0-10 mi/hr
Color of Plume: White	Detached Plume: No
Interference of Steam Plume: Yes	
Duration of Observation: 75 minutes	

Summary of Data:

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)
1	2	0.0	0
2	10	0.8-2.5	1.9

The recovery furnace associated with smelt tank G operates at an equivalent pulp production rate of 300 tons per day.

6.1.3 Lime Kilns

Particulate data obtained on four lime kilns tested by EPA are presented in Figure 6-4. Data obtained by the mills and state agencies are also presented. The particulate emissions from each lime kiln are controlled by a venturi scrubber. Visible emissions were recorded during two tests on Kiln L. Normally it is difficult to take opacity readings at lime kilns due to steam interference at the stack. The six-minute opacity averages are presented, but are not considered to be a sufficient base upon which to base a visible emissions standard.

Lime Kiln D

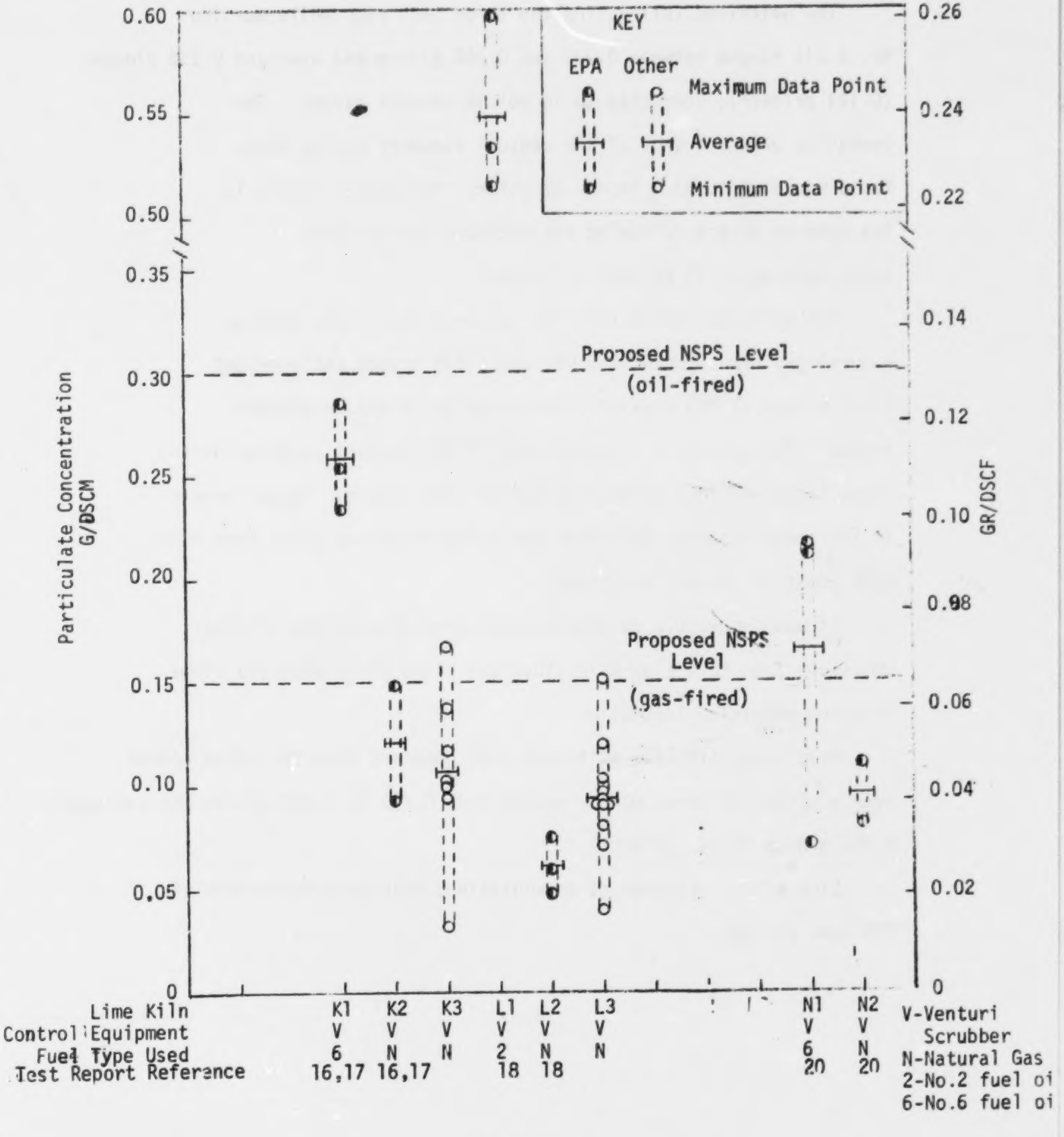
Particulate emissions from lime kiln D ranged between 0.142 and 0.343 and averaged 0.228 g/dscm (0.10 gr/dscf) during the EPA tests.[14] Oxygen levels in the exhaust stream following the scrubber were less than 10 percent by volume. These data are the results of three test runs conducted while the kiln was burning natural gas. The operating pressure drop of the venturi scrubber during these tests was 22-25 inches, water gauge. Weather conditions existing during the EPA tests did not permit opacity observations to be recorded.

This kiln operates at an equivalent pulp production rate of about 570 tons per day.

These data are not representative of the best emission control level for particulate emissions from lime kilns, and therefore do not substantiate the proposed standards.

Figure 6-4

Particulate Concentrations in Control System Exhaust from Lime Kilns Used in the Kraft Pulping Industry



Lime Kiln K

Lime kiln K was tested by EPA while burning both natural gas and No. 6 oil.[16]

The emissions (K1) during the three test runs while burning No. 6 oil ranged between 0.233 and 0.286 g/dscm and averaged 0.258 g/dscm (0.121 gr/dscf), corrected to 10 volume percent oxygen. The operating pressure drop of the venturi scrubber during three tests was 31.0 to 33.0 inches of water. The oxygen levels in the exhaust stream following the scrubber during these tests were about 11 percent by volume.

The emission (K2) during the two test runs while burning natural gas ranged between 0.092 and 0.149 g/dscm and averaged 0.121 g/dscm (0.053 gr/dscf), corrected to 10 volume percent oxygen. The operating pressure drop of the venturi scrubber during these tests was 26.5 to 31.0 inches of water gauge. Oxygen levels in the exhaust stream following the scrubber during these test runs were about 11 percent by volume.

It was impossible to obtain meaningful data on the visible emissions from this lime kiln since the plume mixed with the plume from the adjoining lime kiln.

Data on particulate emissions (K3) obtained from the state agency over a period of seven months ranged from 0.032 to 0.167 g/dscm and averaged 0.107 g/dscm (0.047 gr/dscf).

Lime kiln K operates at an equivalent pulp production rate of 320 tons per day.

Lime Kiln L

Lime kiln L was also tested by EPA on both types of fuel (natural gas and No. 2 oil) used in this kiln.[18] Three test runs were performed on each fuel. The emissions (L1) during the fuel oil tests ranged between 0.515 and 0.597 g/dscm and averaged 0.548 g/dscm (0.24 gr/dscf). These high particulate levels are concluded to be the results of incomplete combustion of the oil. The operator indicated that they were experiencing difficulties in maintaining the kiln temperatures over any period of time when burning fuel oil. Thus, the operator only burns oil when there is no other alternative.

The emissions (L2) during the natural gas tests ranged between 0.048 and 0.076 g/dscm and averaged 0.061 g/dscm (0.027 gr/dscf). The operating pressure drop of the venturi scrubber during these tests was 15-18 inches of water. The oxygen content of the exhaust was about three percent during these tests.

The visible emission data indicated that the opacity of the residual plume from lime kiln L during the fuel oil tests, Table 6-8, and natural gas tests, Table 6-9, was less than 25 and 10 percent, respectively.

Data (L3) obtained from the operator over a period of three months (11 tests) show that the emissions ranged from 0.039 to 0.151 g/dscm and averaged 0.093 g/dscm (0.04 gr/dscf). These tests were conducted while the lime kiln was burning natural gas. This lime kiln operates at an equivalent pulp production rate of about 500 tons per day.

Table 6-8

Summary of Visible Emissions for Lime Kiln L1

Date: April 30-May 1, 1974
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Location of Discharge: Lime Kiln #3 (Gas-Fired)
Height of Point of Discharge: 100 ft.
Description of Background: Blue sky

Description of Sky: Clear

Distance from Observer to Discharge Point: 200 ft.
Height of Observation Point: Ground
Direction of Observer from Discharge Point: North

Wind Direction: Northwest
Color of Plume: White
Interference of Steam Plume: Yes
Duration of Observation: 5 hrs., 36 1/2 minutes

Wind Velocity: 0-18 mi/hr
Detached Plume: No

Summary of Data:

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Comment
1A	21	5.0-5.8	5.0	
B	23	5.0-5.0	5.0	
2A	20	5.0-5.0	5.0	
B	0	-	-	steam interference
3A	16	5.0-5.0	5.0	
B	1	5.0	5.0	steam interference

Table 6-9

Summary of Visible Emissions for Lime Kiln L2

Date: May 2-3, 1974
Type of Plant: Kraft Pulp Mill
Type of Discharge: Stack
Location of Discharge: Lime Kiln #3 (Oil-Fired)
Height of Point of Discharge: 100 ft.
Description of Background: Sky and clouds

Distance from Observer to Discharge Point: 500 ft.
Height of Observation Point: Ground
Direction of Observer from Discharge Point: Northwest

Description of Sky: Partly cloudy

Wind Direction: Southwest
Color of Plume: White
Interference of Steam Plume: Yes
Duration of Observation: 5 hrs., 46 minutes

Wind Velocity: 5-15 mi/hr
Detached Plume: No

Summary of Data:

Run	No. of 6-Minute Averages	Range of Averages	Average Opacity (%)	Comment
4A	13	5.0-9.8	6.0	
B	0	-	-	steam interference
5A	21	5.6-14.2	10.5	
B	0	-	-	steam interference
6A	22	10.0-15.0	12.1	
B	0	-	-	steam interference

Lime Kiln N

Lime kiln N was also tested by EPA on both types of fuel used (natural gas and No. 6 fuel oil).[20] Three test runs were performed using each fuel. The emissions during the tests when No. 6 fuel oil was burned ranged between 0.07 and 0.22 g/dscm and averaged 0.165 g/dscm (0.072 gr/dscf).

The emissions (N2) during the natural gas tests ranged between 0.08 and 0.11 g/dscm and averaged 0.095 g/dscm (0.041 gr/dscf). The operating pressure drop of the venturi scrubber during these tests was about 18 inches of water.

It was impossible to obtain meaningful visible emission data during the particulate test since the plume mixed with the plume from the other lime kiln.

Effect of Fuel on Lime Kiln Particulate Emissions

Testing was performed on more than one type of fuel on several of the lime kilns, since the results of the testing on lime kiln K indicated that the controlled emissions depended on the type of fuel used. The difference in the controlled particulate levels when using No. 6 oil and natural gas seems to be the result of the added particulates produced by inefficient combustion of No. 6 oil. The black color observed on the sampling filters supports this conclusion.

6.2 TRS EMISSIONS

6.2.1 Digesters and Multiple-Effect Evaporators

At least 23 U.S. mills incinerate noncondensable gases from digesters and multiple-effect evaporators in lime kilns.[27] TRS remaining from incomplete combustion of the noncondensables is difficult to distinguish from TRS normally emitted by the lime kiln. To determine TRS emission levels that can be achieved by combustion, EPA measured emissions at a plant that combines noncondensable gases from a continuous digester and multiple-effect evaporator and burns them in a separate incinerator.[23]

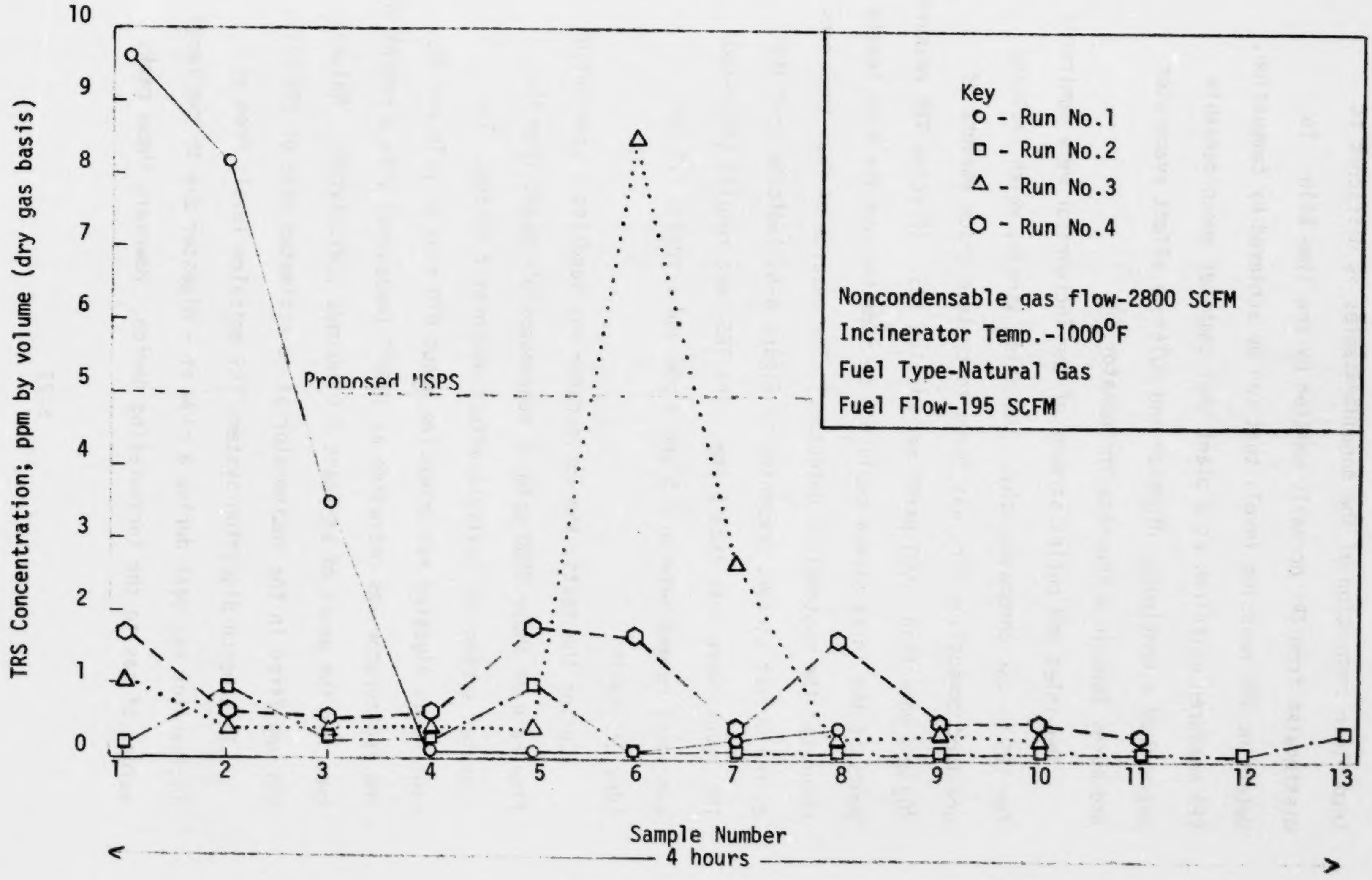
The inlet and outlet streams of the incinerator were monitored for TRS by gas chromatography. The inlet stream, which included premixed combustion air, was found to contain trace amounts of SO_2 and more than 1,000 parts per million TRS. (Precise TRS measurements of the inlet stream could not be made because the high levels saturated the photometric detector.) The results of four test runs on the outlet stream, presented in Figure 6-5, indicate that the TRS levels were less than 5 ppm. The TRS test results (four-hour averages) ranged between 0.5 and 3 ppm and averaged 1.5 ppm (dry gas basis).

During the tests, the incinerator was handling a combination flow rate of abour 2800 scfm of noncondensable gases from the digester system and multiple-effect evaporator system. The continuous digester was producing about 670 tons of pulp per day. The incinerator was operating at 1000°F (measured) with a retention time for the gases of at least 0.5 seconds (calculated). Natural gas was fired in the incinerator at an estimated rate of 195 scfm.

In a batch digestion system, TRS emission levels from an incinerator may peak during a blow of a digester due to the large surges of gas to the incinerating device. However, these peaks

Figure 6-5

TRS Concentration From Incinerator Burning Noncondensables[24]



can effectively be avoided by preventing these large surges of gas by using either large spherical tanks equipped with a movable nonporous diaphragm or conventional gas holders.

6.2.2 Brown Stock Washing System

Vent gases from the brown stock washers are used as combustion air in recovery furnaces at three mills (two in U.S.). One of these mills has more than 4 years of on-line experience. The company reports that initial problems with corrosion of equipment have been eliminated and that no significant operating problems have appeared.

Incineration of brown stock washer gases in the furnace appears to have little effect on the TRS emissions from the recovery furnace. The results of tests by EPA on furnace B, Figure 6-6, show that when the gases from the brown stock washers are incinerated in the furnace, the TRS emissions are less than 5 ppm.

6.2.3 Black Liquor Oxidation Tanks

All mills currently vent the gases from black liquor oxidation (BLO) tanks to the atmosphere. Since the volume of the vent gases from BLO tanks are large (10 to 50 CFM/TPD), it is anticipated that the gases will be used as combustion air with the brown stock washer gases in the recovery furnace. The gases will be fired into the furnace with the combustion air. This control technique is considered feasible if the entrained water in the BLO gases is removed by using condensers.[28,29]

6.2.4 Recovery Furnaces

TRS emissions from three recovery furnaces were measured by EPA. The results of these EPA tests are presented in Figure 6-6. These data are four-hour averages. The emissions were monitored simultaneously with a gas chromatograph and a coulometric titrator. Continuous monitoring data obtained by operators and reported to state control agencies on two recovery furnaces are also reported in Figures 6-7 and 6-8. These TRS data are daily averages and are not used to substantiate the proposed standard. They are included to give an indication of long term emission control performance.

Furnace A

Furnace A, which has a direct-contact evaporator, employs a black liquor oxidation system to control its TRS emissions. The recovery furnace is designed for an equivalent pulp production rate of 657 tons per day and was operating near design capacity during the EPA testing. Furnace A was tested over a six-day period by EPA.[1] Simultaneous analyses by gas chromatography, the reference test method, and an EPA coulometric titrator were consistently in agreement and showed TRS levels less than 5 ppm on a four-hour average. Daily average TRS emissions from Furnace A obtained from the mill operator are presented in Figure 6-7. These data were obtained over a period of 15 months by the operator with a coulometric titrator.

Furnace B

Furnace B TRS emissions are controlled by maintaining proper furnace operation for TRS combustion and eliminating the direct-contract evaporator from the black liquor concentrating system.

Figure 6-6

TRS Emissions From Recovery Furnace Systems Averaged For Periods Of Four Hours

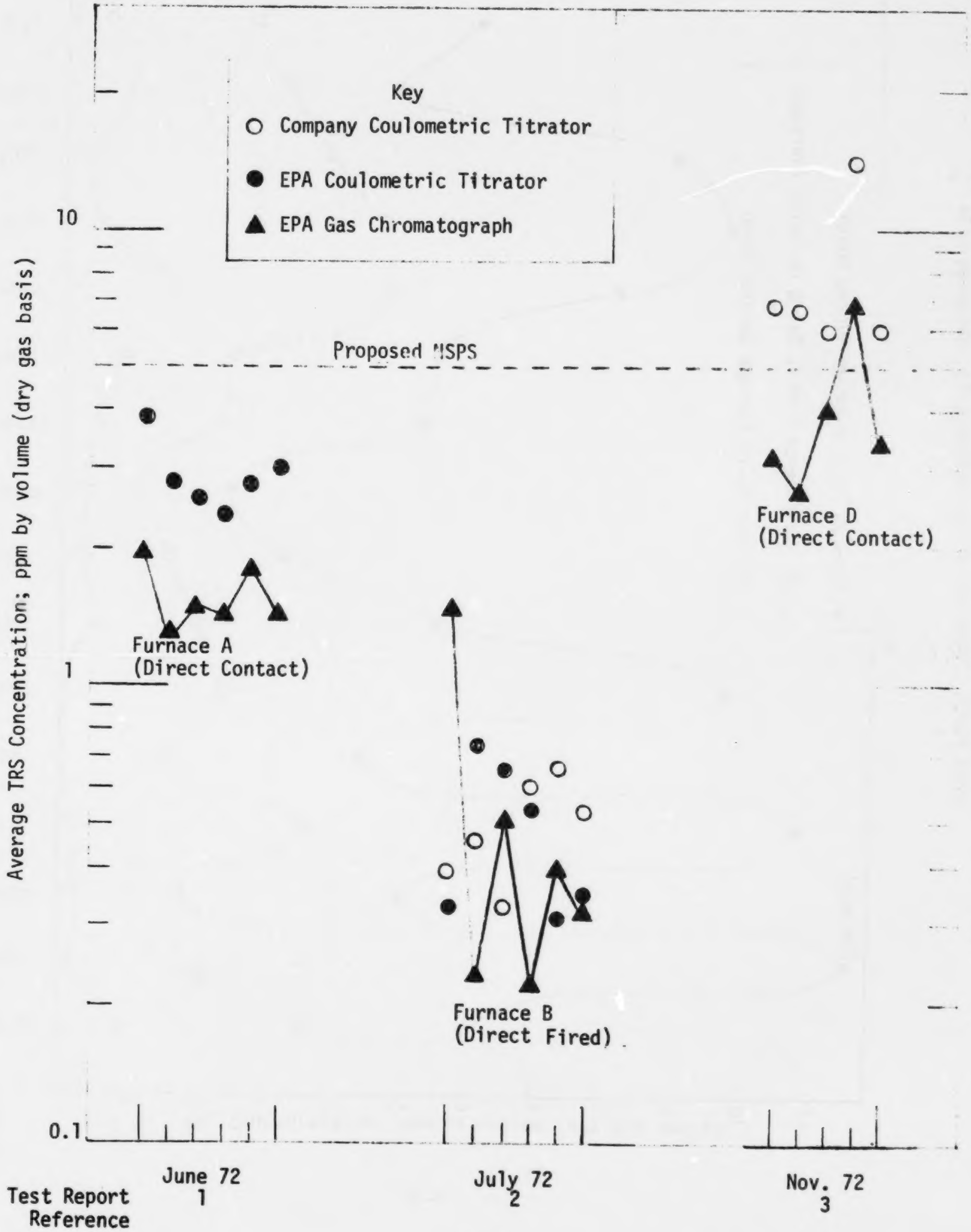
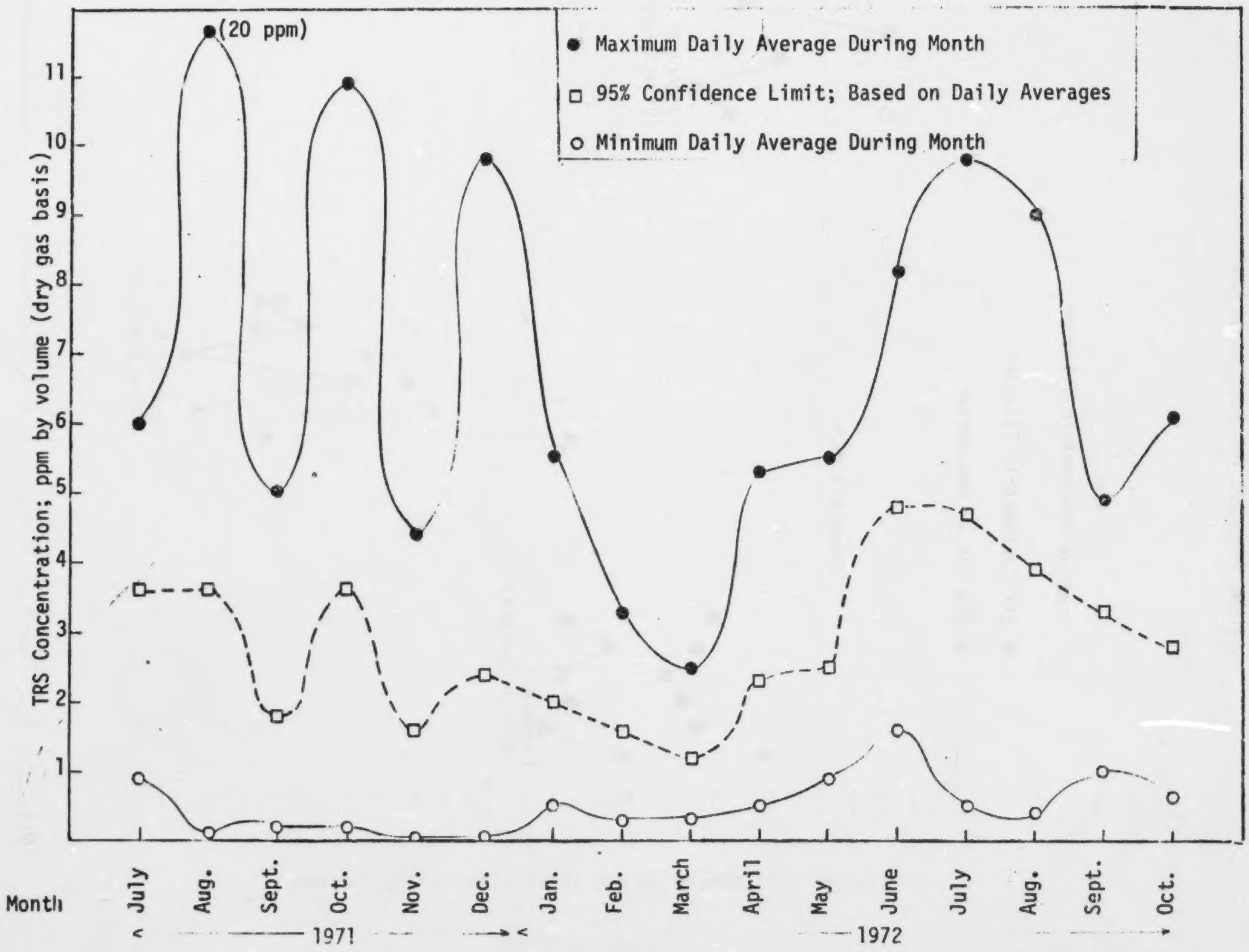


Figure 6-7. TRS EMISSIONS FROM DIRECT CONTACT RECOVERY FURNACE SYSTEMS WITH BLACK LIQUOR OXIDATION (FURNACE A), OPERATOR DATA [37]



Noncondensable gases from the brown stock washers are incinerated in this recovery furnace. Furnace B is designed for an equivalent pulp production rate of 300 tons per day; during the EPA testing, the furnace was operating at a pulp production rate of about 345 tons per day, 15 percent above the rated capacity. Emission measurements were also made over a 7-day period by EPA. Simultaneous analyses by gas chromatography, and EPA coulometric titrator and the operator's coulometric titrator consistently agreed. The results of the EPA tests showed four-hour average TRS emissions less than 1 ppm.[2] TRS emissions from Furnace B obtained from the operator are presented in Figure 6-8. These data were obtained over a 26-month period by the operator with a coulometric titrator. These daily averages are not as stringent as the proposed four-hour average standard. The data are presented as an indication of long-term performance of this facility.

Furnace D

Furnace D was tested over a 5-day period by EPA.[4] The TRS emissions from Furnace D, which has a direct-contact evaporator, are controlled by employing a black liquor oxidation system and maintaining proper furnace operation for TRS combustion. Four out of five analyses by gas chromatography indicated TRS levels less than 5 ppm. The data are presented in Figure 6-6.

Furnace H

Furnace H, which does not have a direct-contact evaporator, was not tested by EPA. Continuous monitoring data (daily averages) was obtained from the local control agency for a period of 8 months.[29]

Figure 6-8. TRS Emissions From Indirect Contact Furnace[35] System (Furnace B) Operator Data

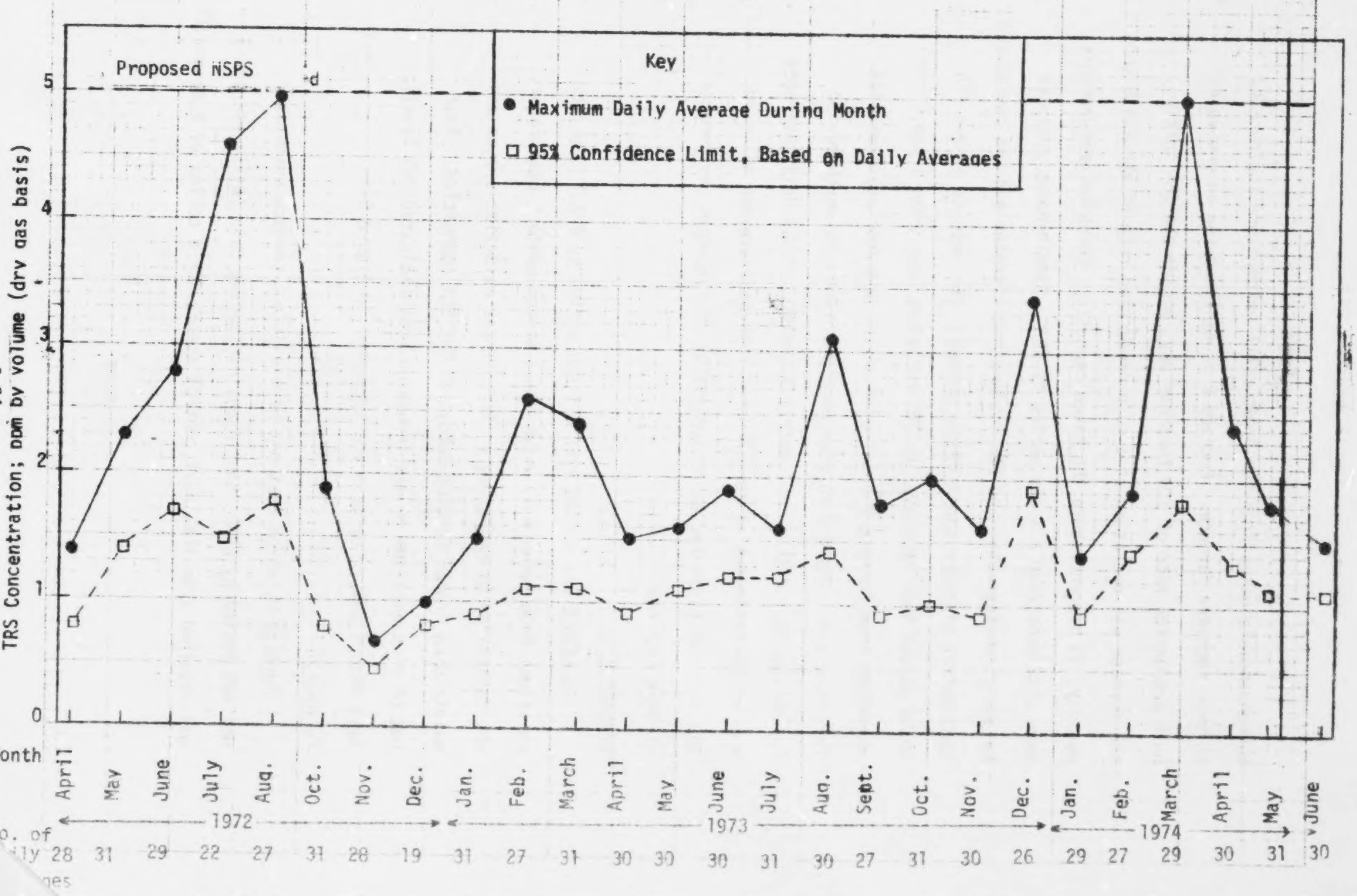


Figure 6-9

TRS Emissions from Indirect Contact Recovery **Furnaces** (Furnace H), Operator Data[35]

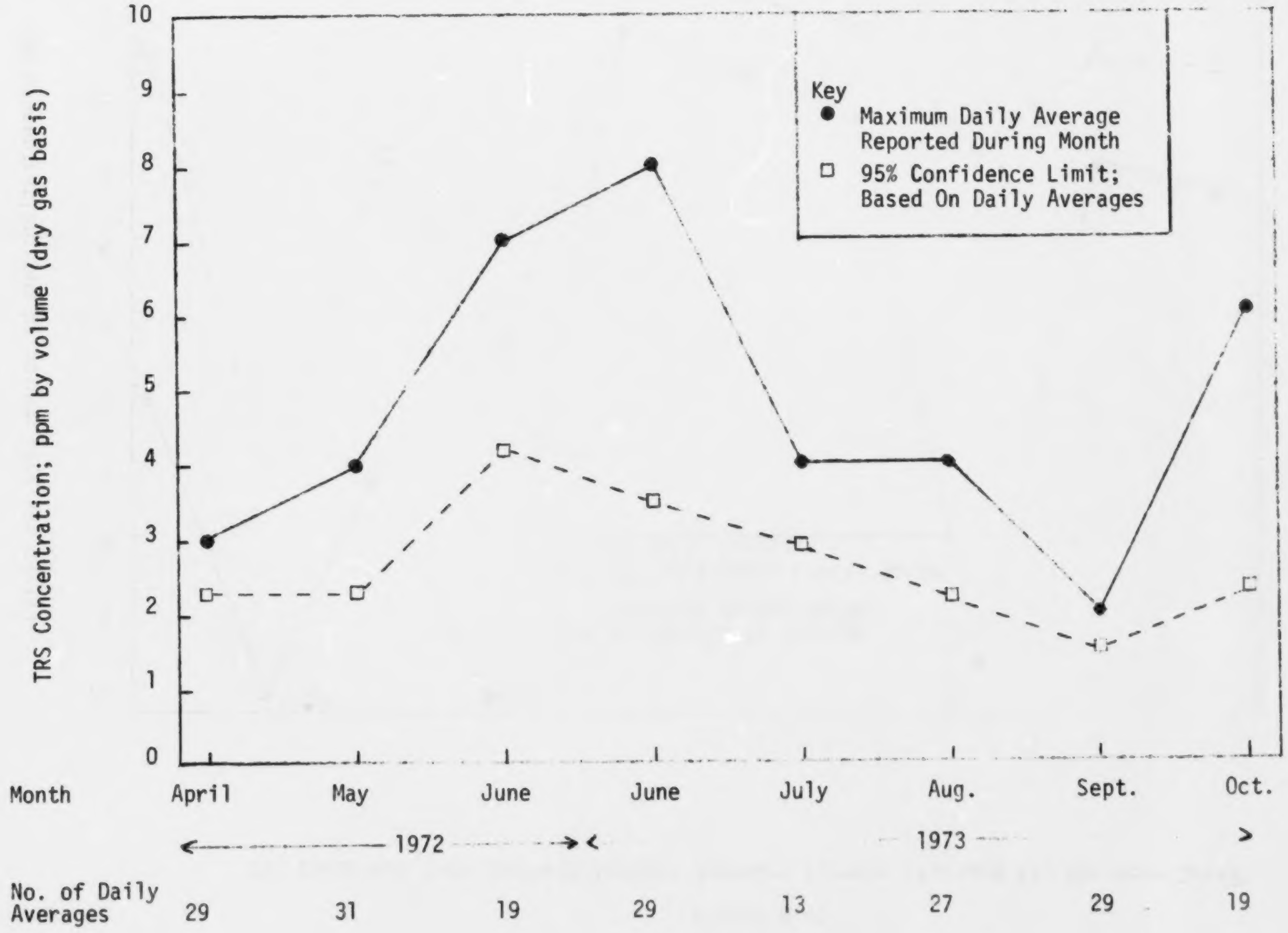
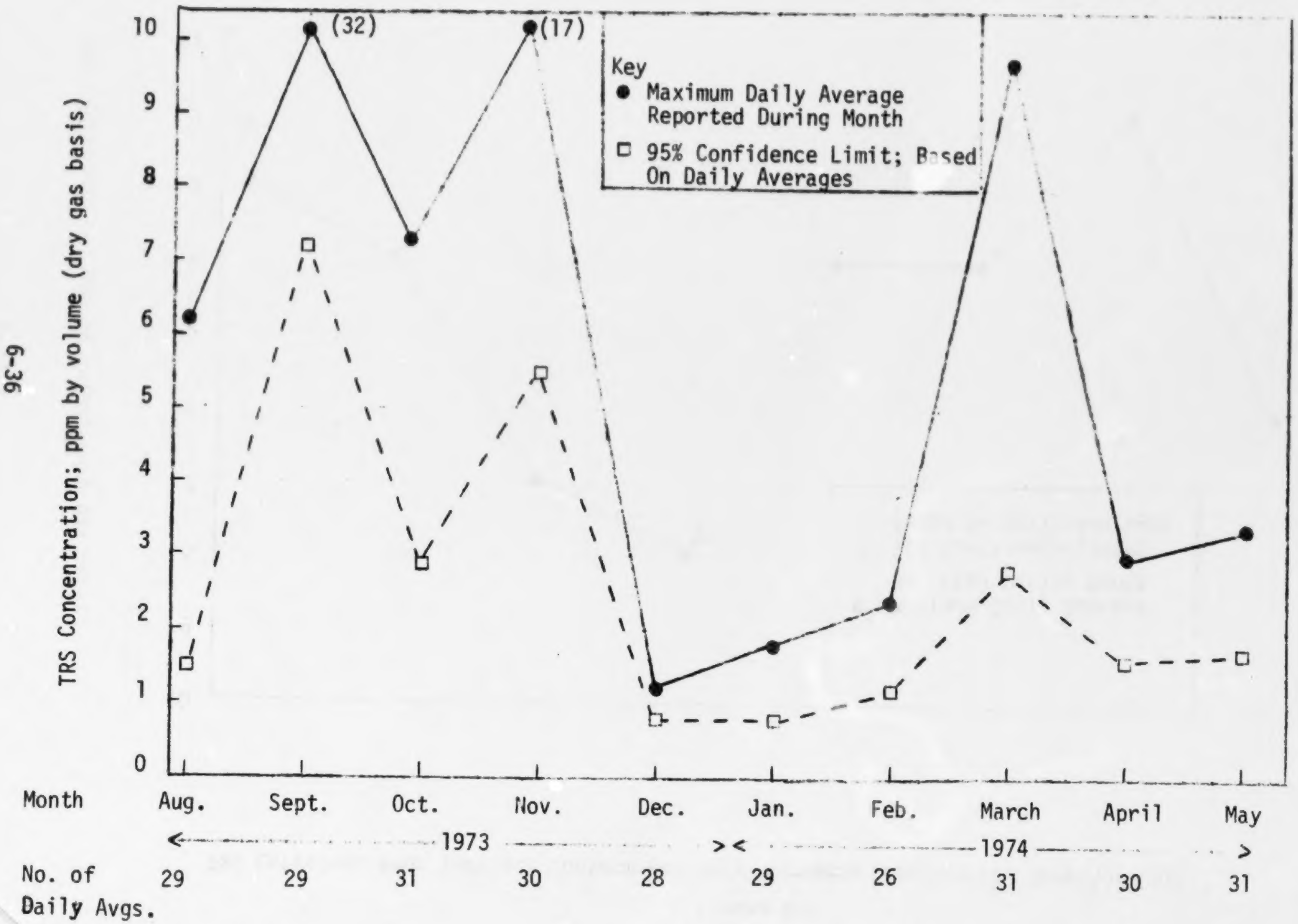


Figure 6-10

TRS Emissions from Indirect Contact Recovery Furnace (Furnace K), Operator Data[35]



These data, Figure 6-9, show that the TRS emissions can be maintained below 5 ppm. Furnace H operates at an equivalent pulp production rate of about 200 tons per day. These daily averages are not as stringent as the proposed four-hour average standard. The data are presented as an indication of long-term performance of this facility.

Furnace K

Furnace K, which does not have a direct-contact evaporator, was not tested for TRS by EPA. Continuous monitoring data was obtained from the local control agency for a period of 10 months.[28] These data, presented in Figure 6-10, indicate that the TRS emissions can be maintained below 5 ppm on a daily average. Since daily averages are not as stringent as four-hour averages, these data do not actually support the proposed standards. They do, however, indicate long-term performance, and are included for this reason.

6.2.5 Smelt Dissolving Tank

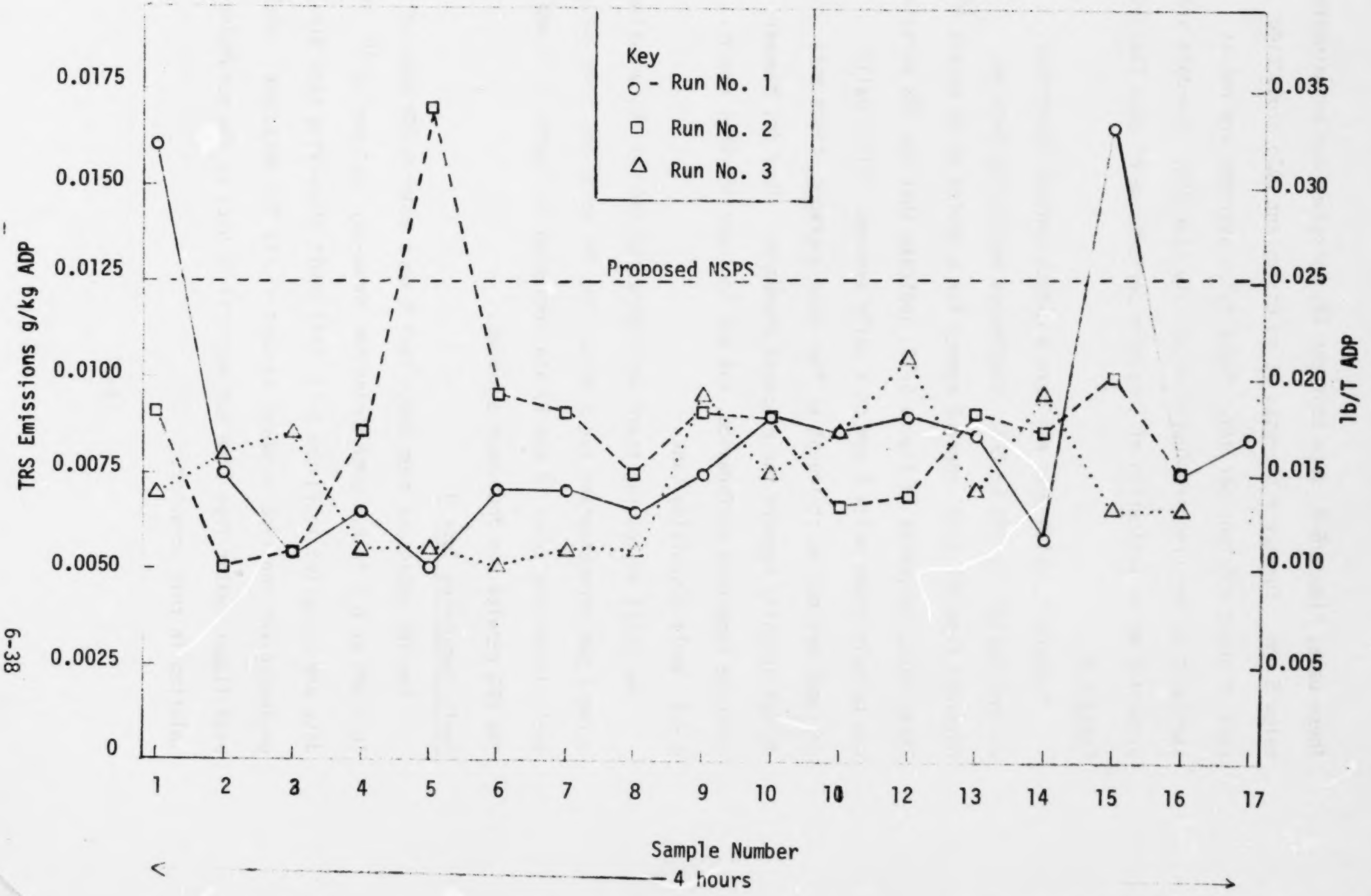
Two smelt dissolving tanks were tested by EPA for TRS emissions using a gas chromatograph for 3 days. The TRS emissions from these smelt dissolving tanks (D and E) are presented in Figures 6-11 and 6-12. The EPA results are four-hour averages.

Smelt Dissolving Tank D

The TRS emissions from smelt tank D were under 0.008 g/kg ADP (0.016 lb/T ADP or 6.9 to 8.8 ppm) during the three-day test period.[10] The data are presented in Figure 6-11. This smelt dissolving tank also employs a wet fan type scrubber to control its TRS emissions. Weak wash liquor (water from lime mud washers) is used as the scrubbing solution in this scrubber.

Figure 6-11

TRS Mass Emission Rate From Smelt Dissolving Tank D[10]



Smelt Dissolving Tank E

The TRS emissions from smelt tank E were under 0.004 g/kg ADP (0.0079 lb/T ADP or 1.8 to 2.8 ppm) during the three-day test period.[11] The data are presented in Figure 6-12. This smelt dissolving tank employs a wet fan type scrubber to control its TRS emissions. Fresh water is used as the scrubbing solution in the scrubber.

Additional Test Data

A special study, conducted by NCASI personnel in 1970 and 1971, measured TRS emissions from numerous smelt dissolving tanks.[30] The reduced sulfur contributions from 20 smelt tank vents are also summarized and reported in Table 6-10. This table shows that 15 smelt tanks, tested by NCASI, had TRS levels less than 0.013 g/kg ADP (0.025 lb/T ADP or 7 ppm). Table 6-10 also lists the control device and scrubbing solution for each smelt dissolving tank tested. Based on this information, the most effective control device for TRS emissions is a wet scrubber using fresh water.

6.2.6 Lime Kilns

Three lime kilns were tested for TRS emissions by EPA, and the data is summarized in Figure 6-13. TRS emissions were monitored with a gas chromatograph. These data are four-hour averages. Continuous monitoring data (daily averages) obtained on one of these lime kilns are also reported in Figure 6-13.

Lime Kiln D

The TRS emissions from lime kiln D during the EPA tests ranged between 2.8 and 24.1 ppm and averaged 9.8 ppm.[14] These data, Figure 6-14, are the results of six four-hour runs. TRS emissions from kiln D are controlled by maintaining good process controls. The cold-end

Table 6-10

TRS Emissions From Smelt Dissolving Tanks Used In The Kraft Pulping Industry

Mill	TRS			Particulate Control Device	Scrubbing Solution
	g/kg ADP	lb/T ADP	ppm		
EPA Test Results					
E	0.004	0.0079	1.8-2.6	Wet Fan Scrubber	Fresh Water
D	0.008	0.016	6.9-8.8	Wet Fan Scrubber	Weak Wash
NCASI Study Results					
II	0.005	0.01	1.0-2.5	None	-
III	0.06	0.12	10-40	Packed Tower	Weak Wash and Contaminated Condensate
	0.005	0.01	<0.1-1.0	Packed Tower	Fresh Water
	<0.005	<0.01	<0.1-0.6	Spray	Fresh Water
IV	0.02	0.04	1.0-20.0	Showers	Fresh Water
	0.02	0.04	3.0-26.0	Showers	Fresh Water
	0.04	0.08	10-35	Demister	Fresh Water
	0.055	0.11	20-66	None	Fresh Water
V	0.005	0.01	1.5-3.0	Demister	Fresh Water
	0.01	0.02	4-9	None	-
	<0.0005	<0.001	<0.1	Demister	Fresh Water
	<0.0005	<0.001	<0.1	None	-
VI	<0.005	<0.01	2.0-4.0	Demister	Fresh Water
	<0.005	<0.01	0.8-1.8	None	-
	<0.0005	<0.001	<0.1	Demister	Fresh Water
VII	0.01	0.02	4-6	Showers	Fresh Water
	0.015	0.3	5-8	Showers	Fresh Water
VIII	0.005	0.01	2-5	Demister	Contaminated Condensate
IX	<0.0005	<0.001	<0.1	None	-
X	0.01	0.02	4-6	Demister	Fresh Water
	0.005	0.01	4-6	Demister	Fresh Water
	0.005	0.01	2-6	Demister	Fresh Water
XI	<0.0005	<0.001	<0.1	Packed Tower	Weak Wash
XII	<0.005	<0.01	1-1.5	Demister	Weak Wash and Contaminated Condensate
	<0.005	<0.01	<0.1-2.5	Demister	Weak Wash and Contaminated Condensate
XVII	0.005	0.01	17-33	Showers	Fresh Water

Figure 6-12

TRS Mass Emission Rate From Smelt Dissolving Tank E

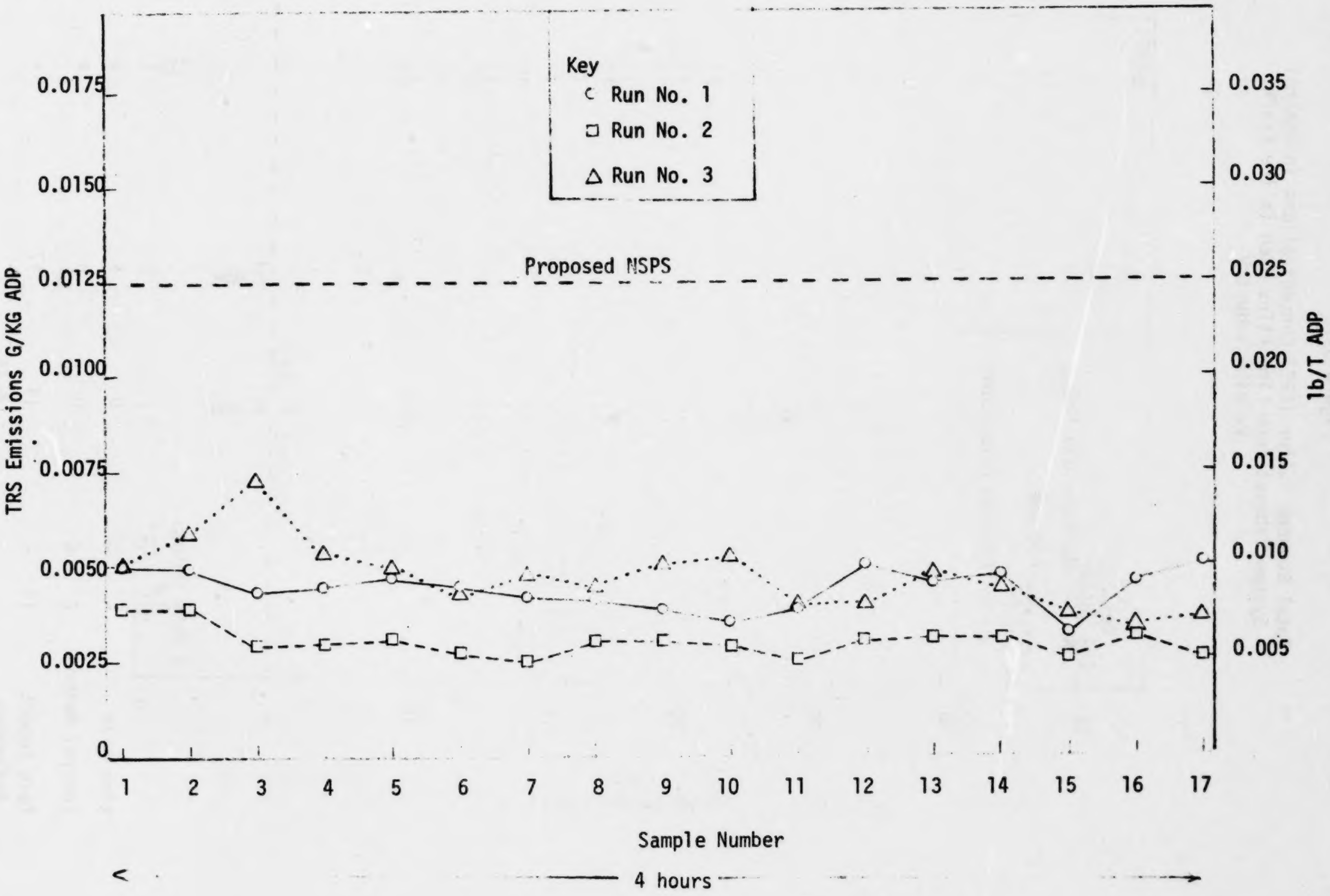
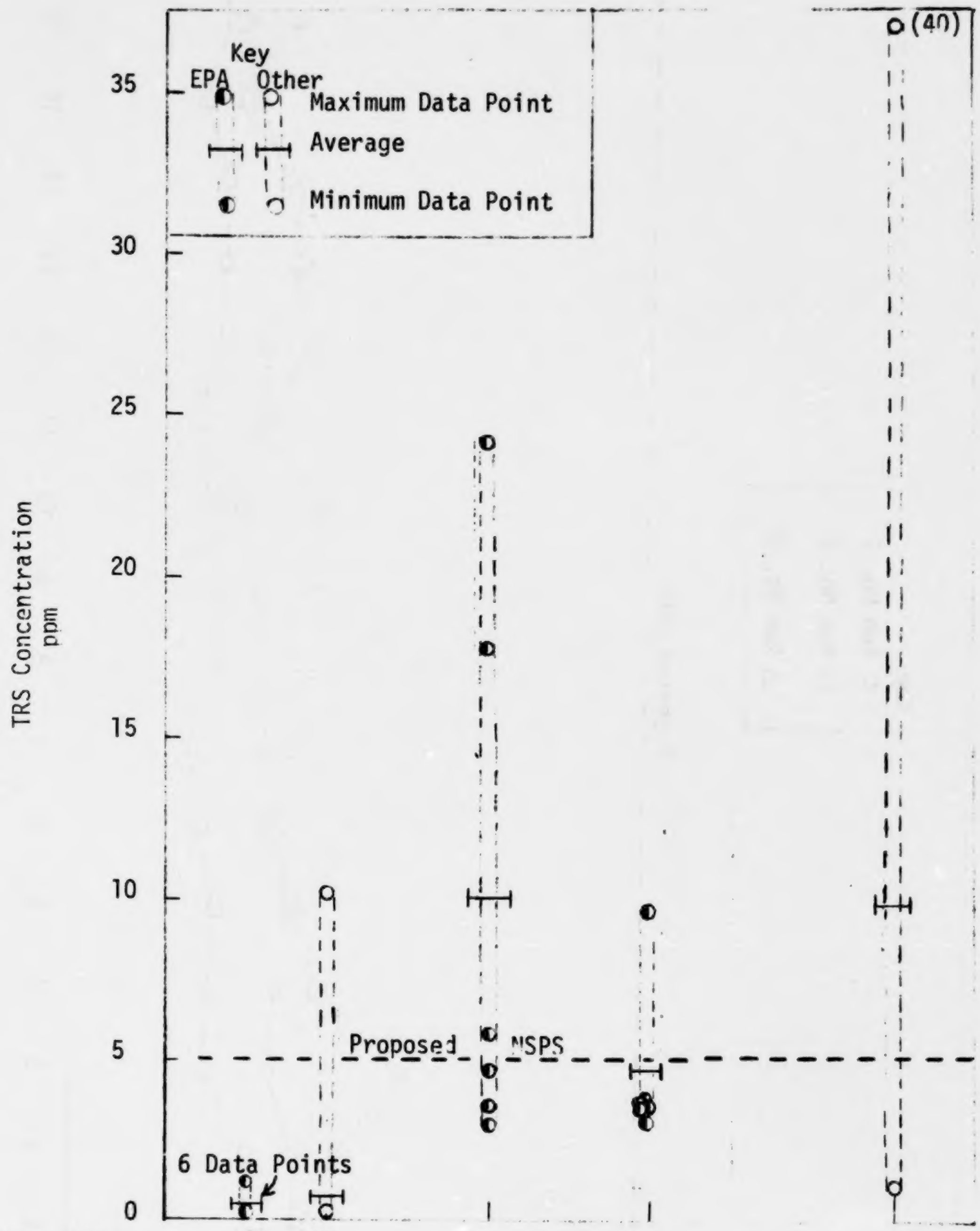


Figure 6-13

Total Reduced Sulfur (TRS) Concentrations in Control System Exhaust From Lime Kilns Used In The Kraft Pulping Industry



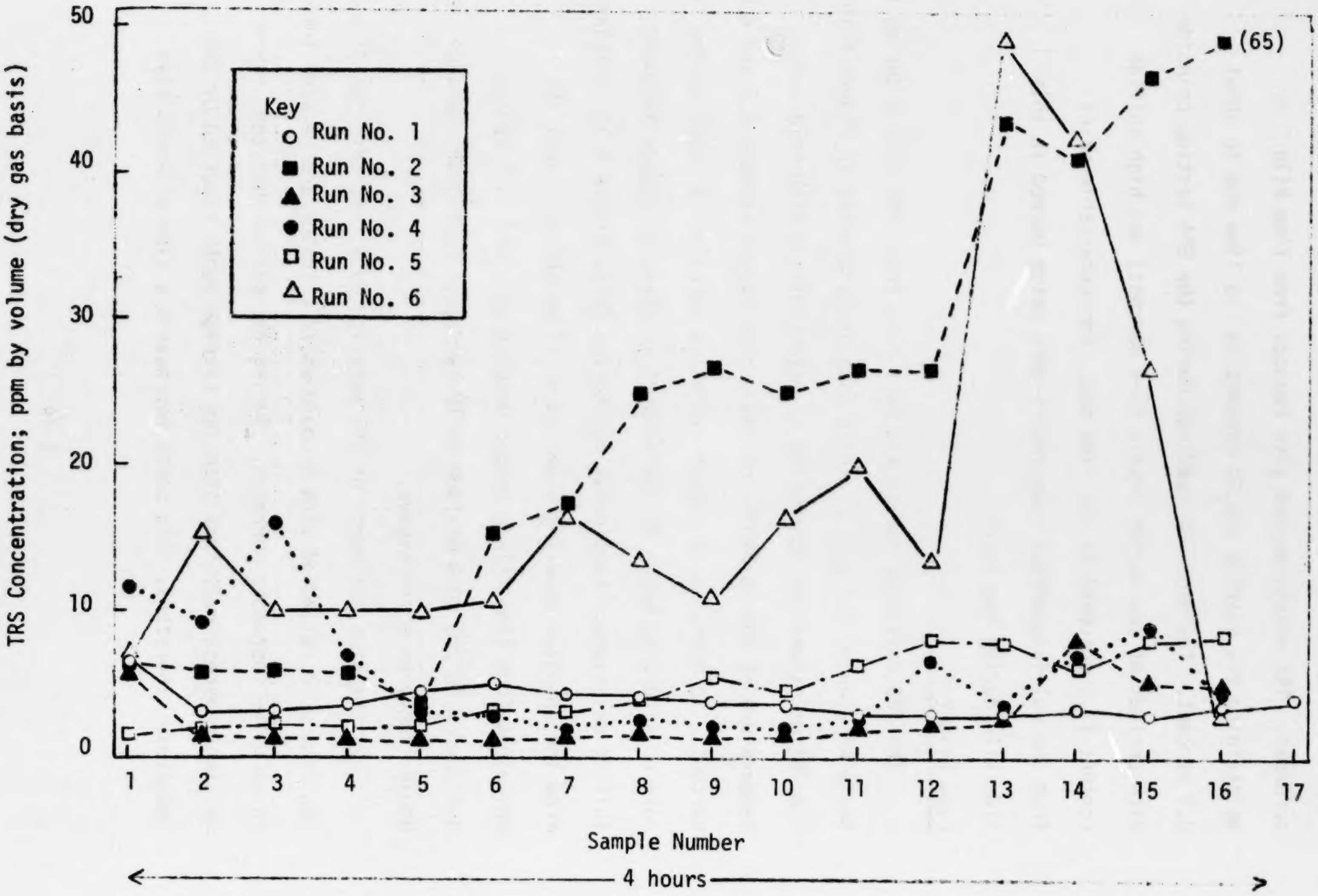
Lime Kiln	E1	E2	D	K	O
Control Method	C	C	P	P	P
Test Report Reference	15	-	14	17	-

C - Process Controls & Caustic Addition

P - Process Controls Only

Figure 6-14

TRS Emission From Lime Kiln System Not Utilizing Caustic Scrubbing (Lime Kiln D; EPA Data)[14]



temperature is maintained at 460 to 540°F and the excess oxygen is held at about 5 to 6 percent. Fresh water is used in the venturi scrubber. TRS emissions are also reduced from lime kiln D by maintaining the sulfide (Na_2S) content in the lime mud to about 0.3 percent. The high TRS readings during the EPA testing coincide with periods of low oxygen levels (2-4 percent) and high sulfide content (1.0 percent) in the lime mud. Noncondensable gases from the multiple-effect evaporators were being burned in this lime kiln during the tests.

Lime Kiln E

The TRS emissions during six test runs from lime kiln E during the EPA tests were under 2.0 ppm.[15] These data are presented in Figure 6-15. The TRS emissions are controlled by maintaining a high cold-end temperature of 555 to 740°F and the excess oxygen between 2.5 and 4.5 percent. In addition, a sodium hydroxide solution is added to the fresh make-up scrubbing water in the venturi scrubber to reduce hydrogen sulfide emissions. Continuous monitoring data, Figure 6-16, obtained from the operator covering a period of 13 months show that TRS emissions from lime kiln E ranged between zero and 10.1 ppm and averaged 0.63 ppm on a maximum daily average. Four-hour averages would likely be a bit higher.

EPA analyzed one month of TRS emission data from this facility.[31] The data were collected with a coulometric titrator and reduced into consecutive four-hour averages. During the period analyzed, there were more excess emissions than the average month reported by the operator. Therefore, this month represents a type of worst case

Figure 6-15

TRS Emissions From Lime Kiln System
Utilizing Caustic Scrubbing (Lime Kiln E; EPA Data)[15]

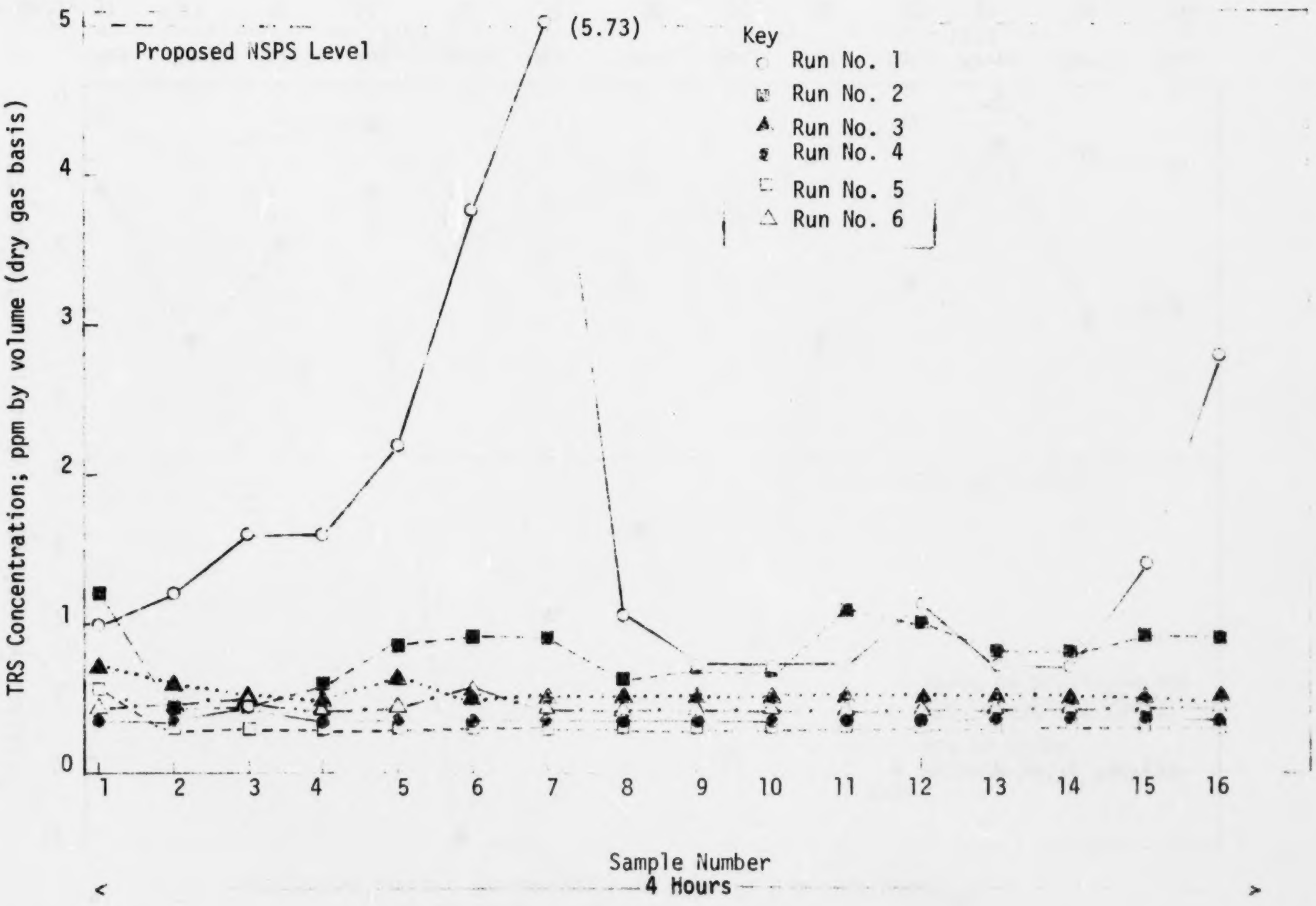
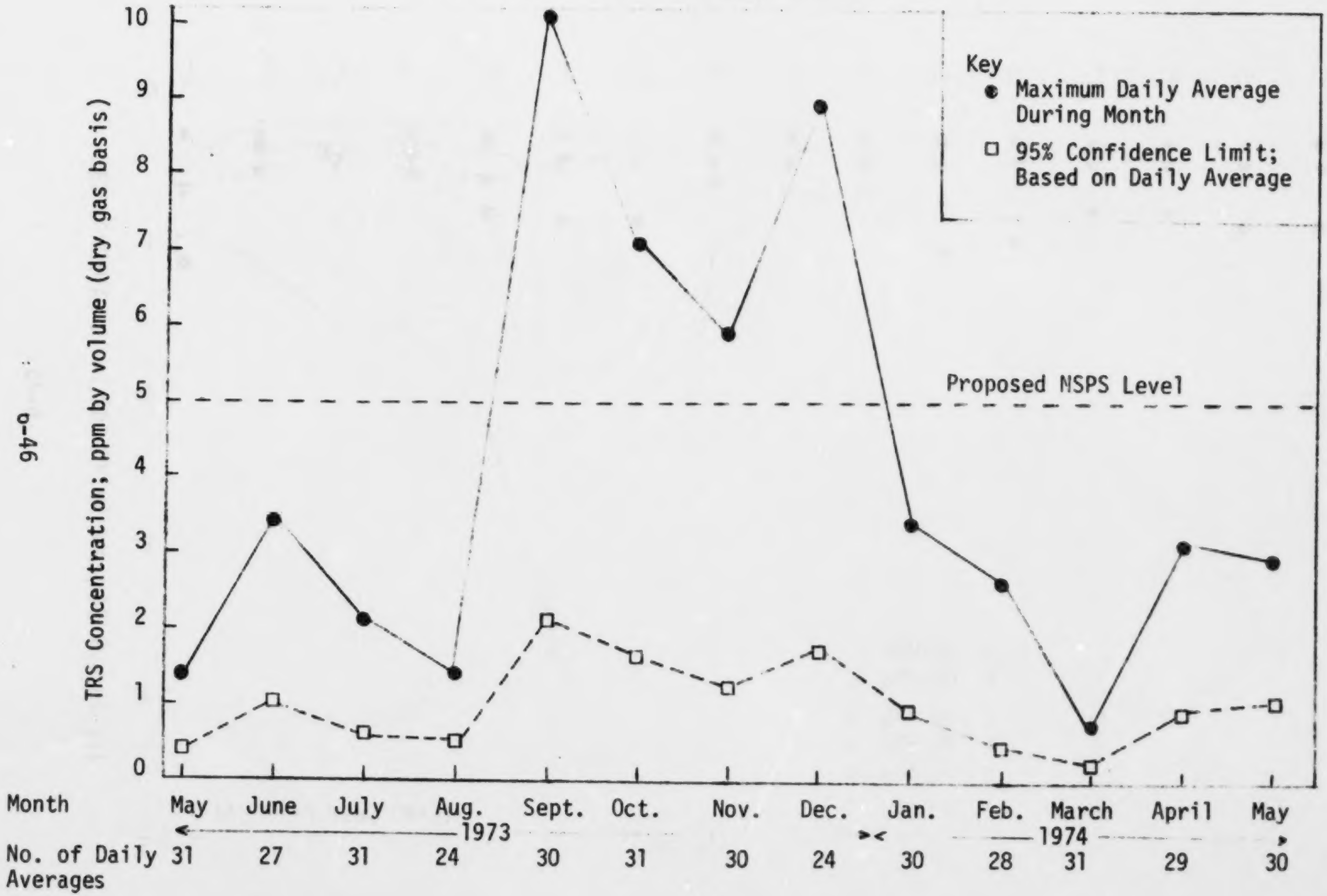


Figure 6-16

TRS Emissions From Lime Kiln System
Utilizing Caustic Scrubbing (Lime Kiln E; Operator Data)[38]



analysis. The results of the study show that the four-hour average TRS emission level was below 5 ppm about 94 percent of the time. The study excluded emissions during periods of start-up, shutdown, and malfunction. Vent gases from the digesters, evaporators, condensate stripper, and miscellaneous storage tanks were burned in the lime kiln during the EPA tests.

Lime Kiln K

The TRS emissions from lime kiln K during the EPA tests ranged between 4.0 and 12.5 ppm and averaged 6.0 ppm.[17] These data, Figure 6-17, are the results of six four-hour test runs. The TRS emissions are controlled by maintaining the cold-end temperature around 700°F and the excess oxygen concentration level in the kiln between 6 to 7 percent. Analyses showed that the sulfide content of the lime mud to kiln K was about 0.4 percent. Fresh water is used as make-up to the venturi scrubber used for particulate control.

Noncondensable gases from the digesters, multiple-effect evaporators, and turpentine system are burned in this lime kiln.

Lime Kiln O

Lime kiln O was not tested by EPA. Continuous monitoring data (daily averages) was obtained from the local agency for a period of 17 months.[32] These data, presented in Figure 6-18, show that the TRS emissions range between 3 and 32 ppm and average 9 ppm on a daily average. Lime kiln O operates at about 3-4 percent oxygen concentration and at about 300°F at the cold end. Fresh water is used as make-up to the venturi scrubber used for particulate control.

Figure 6-17

TRS Emissions From Lime Kiln System Not Utilizing Caustic Scrubbing (Lime Kiln K, EPA Data)[16]

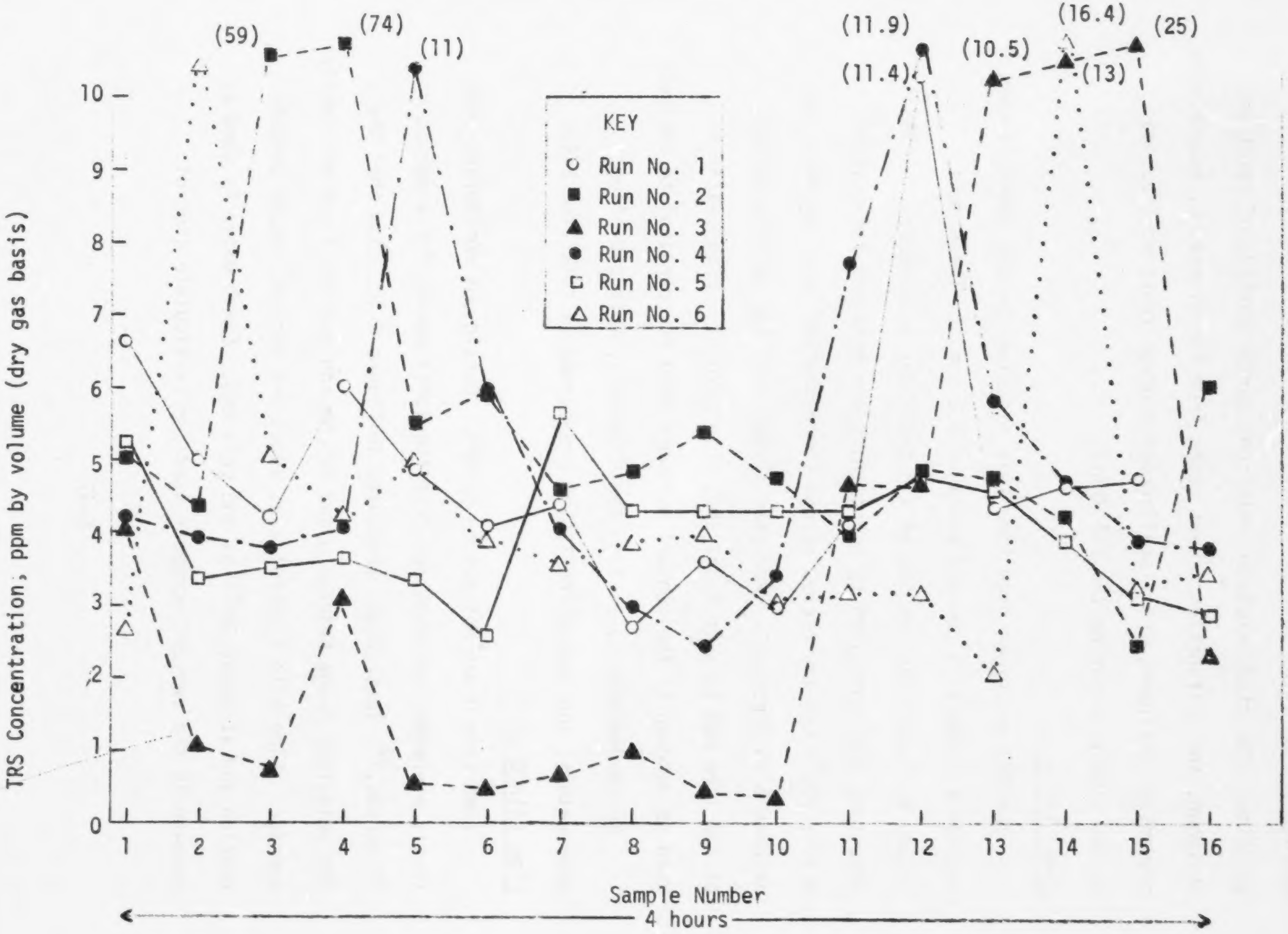
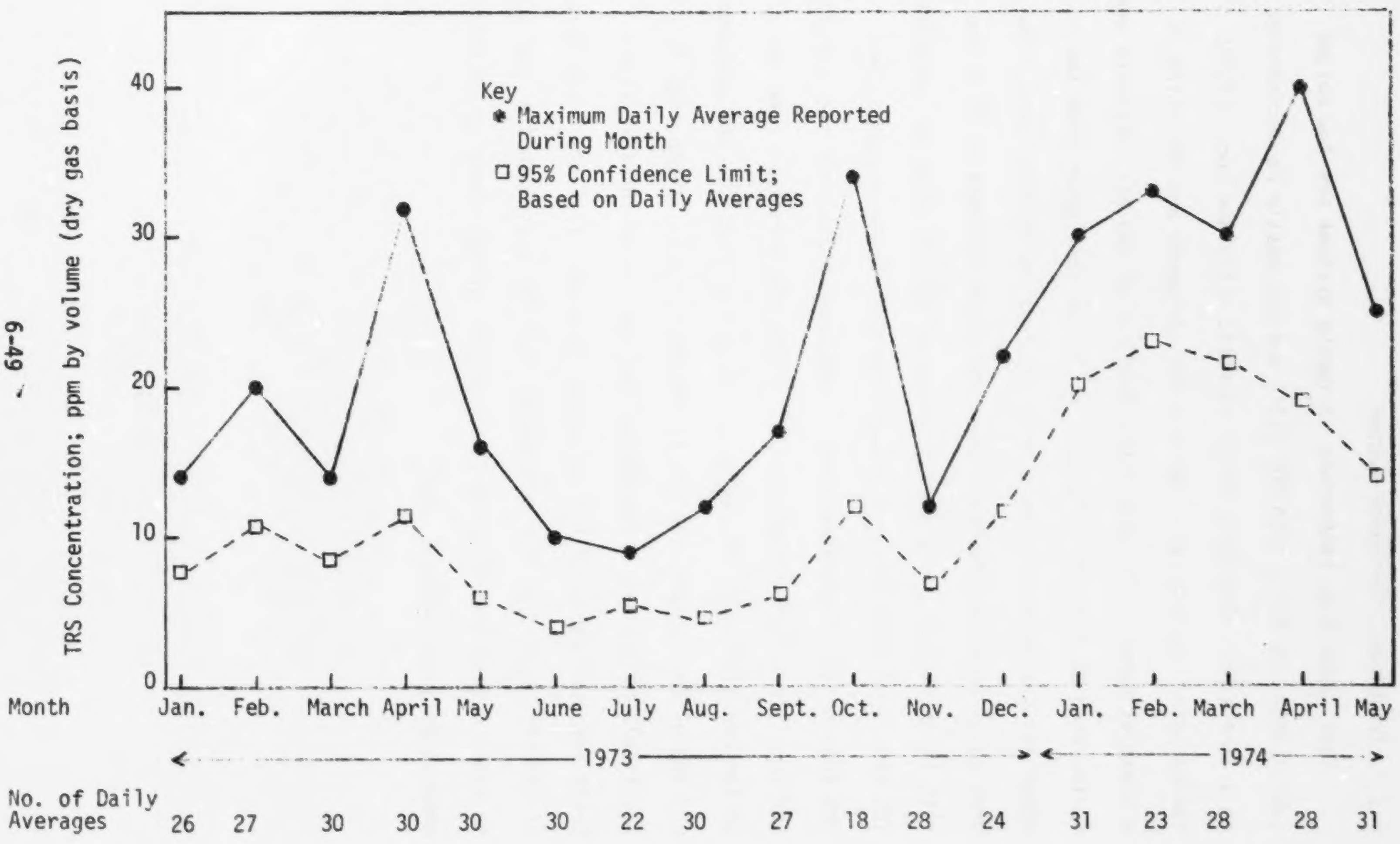


Figure 6-18

TRS Emission From Lime Kiln System Not Utilizing Caustic Scrubbing (Lime Kiln O; Operator Data)[39]



6.2.7 Condensate Stripping System

Vent gases from condensate stripping systems are low volume (about 4000 cfm for a 1000 TPD mill) and can easily be incinerated in a lime kiln. Presently three domestic mills are successfully incinerating these gases. Two are air strippers and the third is a steam stripper. The vent gases from one of the air strippers are incinerated in a recovery furnace while the vent gases from the other air stripper are burned in a separate incinerator unit. The vent gases from the steam stripper are being incinerated in a lime kiln (lime kiln E). The effectiveness of incineration for removing TRS from noncondensable gas streams has been demonstrated in an EPA test on an incinerator burning noncondensables from the digesters and multiple-effect evaporators.[24] Since the emissions from the stripper system are similar to the emissions from the digesters and evaporators and are of low volume, the use of the same control technology is a practical application. Therefore, the results of the incinerator tests are applicable to the emissions from this facility. Incineration of the off-gases from the condensate stripper system in the lime kiln or other combustion device will be capable of achieving an emission concentration of below 5 ppm.

References

1. Air Pollution Emission Test 72-PC-11 (Recovery Furnace A), March 1975.
2. Air Pollution Emission Test 72-PC-13 (Recovery Furnace B), March 1975.
3. Air Pollution Emission Test 73-KPM-2 (Recovery Furnace D), January 1975.
4. Air Pollution Emission Test 74-KPM-5 (Recovery Furnace D), November 1975.
5. Air Pollution Emission Test 74-KPM-13 (Recovery Furnace I), January 1975.
6. Air Pollution Emission Test 74-KPM-12 (Recovery Furnace J), January 1975.
7. Air Pollution Emission Test 74-KPM-15 (Recovery Furnace K), June 1974.
8. Air Pollution Emission Test 74-KPM-17 (Recovery Furnace L), November 1974.
9. Air Pollution Emission Test 72-PC-13 (Smelt Dissolving Tank B), March 1975.
10. Air Pollution Emission Test 74-KPM-5 (Smelt Dissolving Tank D), November 1975.
11. Air Pollution Emission Test 74-KPM-4 (Smelt Dissolving Tank E), November 1975.
12. Air Pollution Emission Test 74-KPM-10 (Smelt Dissolving Tank F), January 1975.
13. Air Pollution Emission Test 74-KPM-9 (Smelt Dissolving Tank G), February 1975.
14. Air Pollution Emission Test 74-KPM-5 (Lime Kiln D), November 1975.
15. Air Pollution Emission Test 74-KPM-4 (Lime Kiln E), November 1975.
16. Air Pollution Emission Test 74-KPM-15 (Lime Kiln K), June 1974.
17. Air Pollution Emission Test 74-KPM-1A (Lime Kiln K), November 1974.
18. Air Pollution Emission Test 74-KPM-17 (Lime Kiln L), December 1974.

19. Air Pollution Emission Test 74-KPM-20 (Lime Kiln M), March 1974.

20. Air Pollution Emission Test 74-KPM-19 (Lime Kiln N), January 1975.

21. Air Pollution Emission Test 74-KPM-11 (Lime Kiln P), January 1975.

22. Air Pollution Emission Test 72-PC-11 (BLO System A), March 1975.

23. Air Pollution Emission Test 73-KPM-1A (Noncondensable Incinerator C), January 1975.

24. Air Pollution Emission Test 73-KPM-1B (Noncondensable Incinerator C), January 1975.

25. Air Pollution Emission Test 73-KPM-2A (Brown Stock Washers and BLO System D), January 1975.

26. Personal communication with S. Snader, Manager of Engineering and Design, Koppers Company, September 17, 1974.

27. Memo from James Herlihy (EPA) to James Durham (EPA) on the Air Pollution Control at U.S. Kraft Mills (State of the Art), May 18, 1972.

28. Letter dated November 17, 1972, from Russell O. Blosser of NCASI to Paul Boys of EPA.

29. Letter dated July 23, 1974, from S. T. Potterton of Babcock and Wilcox to J. A. Eddinger of EPA.

30. Factors Affecting Emissions of Odorous Reduced Sulfur Compounds from Miscellaneous Kraft Process Sources, NCASI Technical Bulletin No. 60, March 1972.

31. Reduction of Total Reduced Sulfur Data from a Kraft Pulp Mill Lime Kiln, Emission Standards and Engineering Division, U.S. EPA, December 1975.

32. Monthly Reports to Humboldt County Air Pollution Control District, January 1973 to May 1974.

33. Letter from Andrew Ryfun, Manager of Environmental Services, Brunswick Pulp and Paper Company to James Herlihy of EPA, dated October 5, 1973.

34. Information received by EPA from Buckeye Cellulose Corp. at meeting with industry at Research Triangle Park, N.C., March 7, 1975.

35. Information obtained from the Washington Department of Ecology.

36. Letter from James Farmer of Buckeye Cellulose Corp. to James Herlihy of EPA, dated February 4, 1974.

37. Data supplied to EPA by Champion Paper Company, Pasadena, Texas.

38. Data supplied to EPA by Escanaba Pulp and Paper Company, Escanaba, Michigan, July 2, 1974.

39. Data supplied to EPA by the Humboldt County Air Pollution Control Agency, May 10, 1973 and July 1, 1974.

7. ENVIRONMENTAL IMPACT

The purpose of this chapter is to identify, quantify, and evaluate the positive and negative environmental impacts of the alternative control systems presented in chapter 4 for kraft pulp mills. The impacts on total mass emissions and ambient concentrations of TRS and particulate matter, water supply and treatment requirements, solid waste handling and disposal, noise and radiation, and energy requirements for each alternative system are discussed. Both primary and secondary impacts are considered. Primary impacts are those directly attributable to each alternative control system. Secondary impacts are indirect or induced impacts which arise from the application of these systems. In general, for kraft pulp mills the use of one of the alternative control systems will have an overall beneficial impact on ambient air quality and slight adverse impacts on solid waste handling and disposal, and energy demand. No impacts on water treatment and supply are anticipated. Impacts due to an increase in noise as a result of the use of one of the alternative control systems can be anticipated, but have not been quantified. It is assumed that any increases would be negligible when compared to the existing levels. No impacts due to a change in radiation levels are anticipated as a result of the proposed standards.

A summary of the anticipated secondary environmental effects associated with the alternative control standards is presented in Table 7-1. Impacts on air quality, water supply and treatment, solid waste impact, and energy consumption are identified. These impacts will be discussed in more detail later in this chapter.

Table 7-1. Secondary Environmental Impacts of Individual Control Techniques

AFFECTED FACILITY	CONTROL TECHNIQUE	SECONDARY ENVIRONMENTAL IMPACTS			
		AIR IMPACT	WATER IMPACT	SOLID WASTE IMPACT	ENERGY CONSUMPTION
RECOVERY FURNACE	ESP	Increased Emissions from Power Plant[a]			Increased Power Requirement
	Scrubber	Increased Emissions from Power Plant[a]			Increased Power Requirement
SMELT DISSOLVING TANK	Scrubber	Increased Emissions from Power Plant[a]			Increased Power Requirement
	Demister				
LIME KILN	Caustic Scrubber	Increased Emissions from Power Plant[a]		Possible Handling Problem with NaOH	Increased Power Requirement
	ESP	Increased Emissions from Power Plant[a] and from incinerator unit			Increase in Power Requirement and Added Fuel Requirement for Incinerator
DIGESTER SYSTEM MULTIPLE EFFECT EVAPORATORS CONDENSATE STRIPPER SYSTEM	Incineration in Lime Kiln				Slight Increase in Fuel Requirement
	Separate Incinerator	SO_2, CO, and NO_x emissions			Significant Increase in Fuel Requirement
	Scrubber	Increased Emissions from Power Plant[a]			Increased Power Requirement
BROWN STOCK WASHERS BLACK LIQUOR OXIDATION SYSTEM	Incineration in Recovery Furnace				Slight Increase in Fuel Requirement

Notes:
(a) SO_2, CO, NO_x.

7.1 AIR POLLUTION IMPACT

7.1.1 Primary Impacts

The primary impacts that can be attributed to the use of the alternative control systems can be measured in two ways: the reduction in total mass emissions of TRS and particulate matter and the reduction in the maximum predicted ambient air concentration due to these emissions. As a baseline upon which to measure the impacts due to the proposed standards, an average mill controlled to the levels specified by typical state standards was chosen. These baseline emission values are summarized in chapter 4 as control system number 1. Emission rates were then determined for the facilities controlled with the alternative systems, also summarized in chapter 4.

7.1.1.1 Mass Emissions

The reductions in mass emission levels were calculated on the basis of pounds of pollutant per ton of air-dried pulp produced. Taking into account the average yearly growth rate for the industry, an assumed rate of capacity utilization of 0.95, and the rate of production capacity increase (new capacity plus replacement capacity), the industry-wide reduction in emissions can be calculated.

The total reductions in emissions achievable through the application of the various control techniques discussed in detail in chapter 4, Emission Control Technology, are presented in Table 7-2. By combining the potential reductions for each

TABLE 7-2. Emission Reduction Under Alternative Control Techniques
(1000 ton per day ADP Kraft Pulp Mill)

			Controlled Emissions (lb/ton ADP)		
Particulate	Alternative Control Techniques	Uncontrolled Emissions (lb/ton ADP)	Existing Emission Level(1)	Best Control Level	Reduction
Recovery Furnace	(a) ESP	180	4	2	2
	(b) Scrubber	180	4	14	0
Smelt Dissolving Tank	(a) Demister	8.0	0.5	1.6	0
	(b) Scrubber	8.0	0.5	0.3	0.2
Lime Kiln	(a) 30" venturi	1.0	1.0	0.5	0.5
	(b) ESP	1.0	1.0	0.17	0.83
TRS					
Digester System	(a) Incineration	1.5	0.01(2)	0.01(2)	0
Multiple Effect Evaporators	(a) Incineration	1.0	0.01(2)	0.01(2)	0
Brown Stock Washers(3)	(a) Incineration	0.3	0.3	0.01(2)	0.29
Black Liquor Oxication System(3)	(a) Incineration	0.1	0.1	0.01(2)	0.09
	(b) Oxygen	0.1	0.1	0	0.10
Recovery Furnace	(a) Black liquor oxidation	15.0	0.5	0.15	0.35
	(b) Indirect-contact evaporators	15.0	0.5	0.15	0.35
Smelt Dissolving Tank(3)	(a) Process control	0.2	0.2	0.025	0.175
Lime Kiln	(a) Process control	0.8	0.2	0.050	0.150
	(b) Caustic addition	0.8	0.2	0.025	0.175
Condensate Stripper	(a) Incineration	2.0	0.01(2)	0.01(2)	0

Notes

(1) Existing emission levels based on average state emission standards.
(2) Controlled emission level due to each facility after incineration. In some cases this would actually be equal to zero (0).
(3) These facilities are essentially uncontrolled at this time.

facility, the total reductions attributable to the alternative control systems can be determined.

The reductions in total mass emissions achievable are summarized in Table 7-3. System number 1 is used as the baseline upon which to measure the impacts. The greatest impact on TRS emissions is shown with systems 2 and 5 (81%); on particulate matter with systems 4 and 5 (55%). System 3 shows the least impact.

7.1.1.2. Ambient Concentrations

For the purpose of evaluating the air pollution impacts associated with the implementation of the proposed standards, studies were performed on model kraft pulp mills. The models chosen were of average design and layout as shown in Figure 7-1, and include the eight affected facilities controlled by the proposed standards as well as an average size treatment pond facility. Modeling was performed for plants of 500, 1000, and 1500 tons per day of air-dried pulp (ADP) produced, a range within which the majority of kraft pulp mill capacities fall.

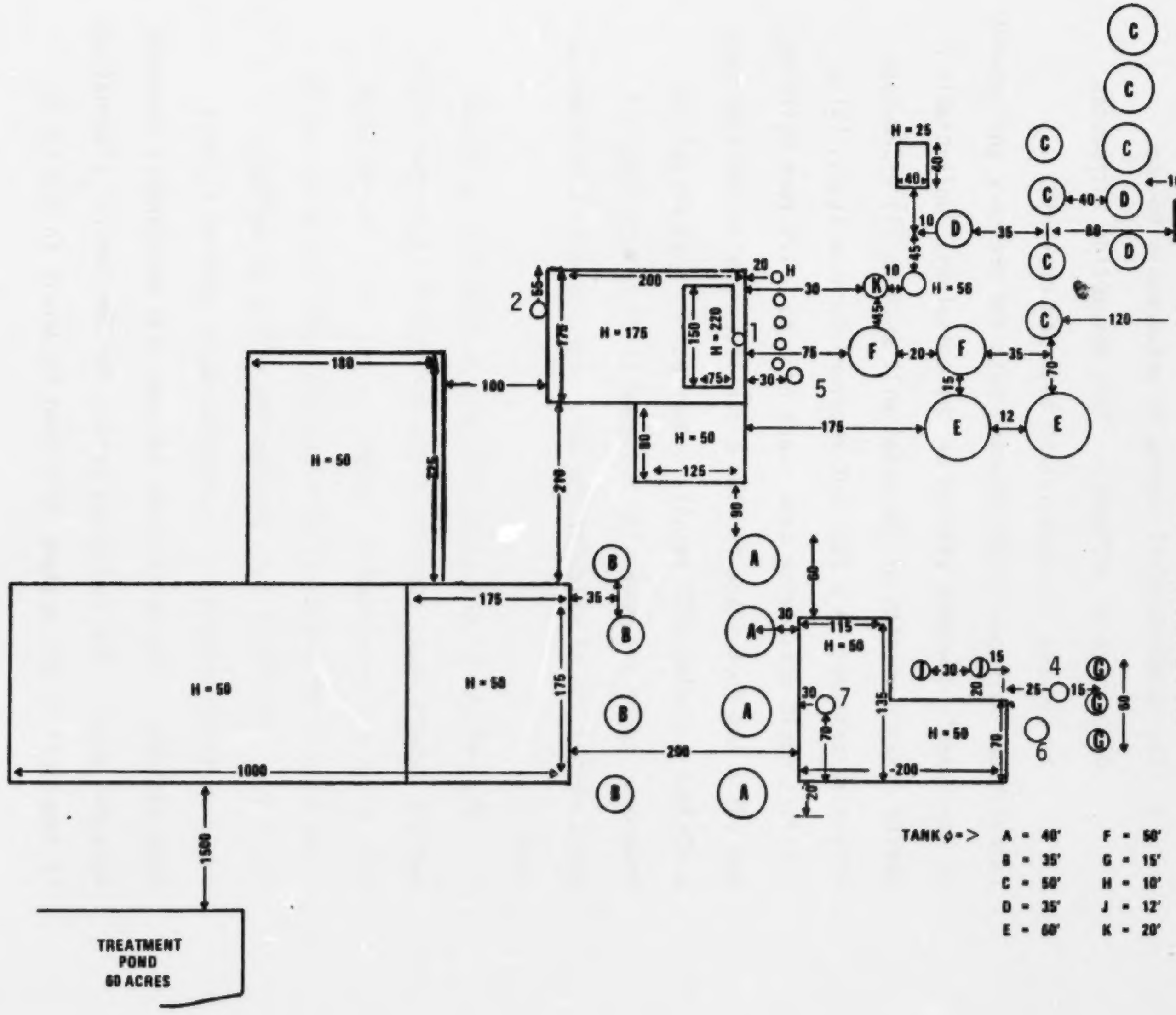
Maximum ground-level concentrations of each pollutant were determined for the emission rates corresponding to each control system. The concentrations decreased predictably with decreases in the emission rates. It was possible to adjust the meteorological conditions of the study to achieve the worst cases that would be expected to occur at and near a kraft pulp mill.

Ambient concentrations of TRS and particulate matter due to the alternative levels of control were calculated using state-of-the-art modeling techniques. These calculations are assumed to be reliable within about a factor of two. The following assumptions

TABLE 7.3. PRIMARY IMPACT OF THE ALTERNATIVE CONTROL SYSTEMS ON MASS EMISSIONS

Alternative Control System	Total Mass Emissions (lb/T ADP)		Total Reductions in Emissions Due to New Source Performance Standards (lb/T ADP and % reduction)	
	TRS	Particulate	TRS	Particulate
1	1.3	5.5	-	-
2	0.25	2.8	1.05 (81%)	2.7 (49%)
3	0.275	2.8	1.025 (79%)	2.7 (49%)
4	0.275	2.47	1.025 (79%)	3.03 (55%)
5	0.25	2.47	1.05 (81%)	3.03 (55%)

FIGURE 7-1. Typical Plant Layout (1000 ton per day kraft pulp mill)


H = 30
H = 25
H = 50
H = 175
H = 220
H = 56
H = 50
H = 50
H = 50
H = 50
H = 50
H = 50
TREATMENT POND 60 ACRES
TANK ϕ =>
A = 40'
B = 35'
C = 50'
D = 35'
E = 60'
F = 50'
G = 15'
H = 10'
J = 12'
K = 20'

Stacks:

1. Recovery Furnace
2. Smelt Dissolving Tank
3. Lime Kiln
4. Digesters
5. Evaporators
6. Brown Stock Washers
7. Oxidation System
8. Condensate Stripper

were applied for the analytical approach:

1. There are no significant seasonal or hourly variations in emission rates for these plants.
2. The plants are located in flat or gently rolling terrain.
3. The meteorological regime is unfavorable to the dispersion of effluents. This assumption introduces an element of conservatism into the analysis.

Calculations were performed assuming both the presence and absence of aerodynamic downwash effects on the emissions. Unfavorable design characteristics of the model mill such as (1) a 220-foot structure adjacent to a 250-foot recovery furnace stack, (2) a 175-foot smelt dissolving tank stack next to a 175-foot building, and (3) a two-foot stack for the black liquor oxidation tank atop a 50-foot building will result in downwash in most situations. However, stacks are generally designed to eliminate downwash and a second set of calculations were made assuming a non-downwash case.

The results of the study that was performed to evaluate maximum ground level concentrations due to emissions from kraft pulp mills are presented in Tables 7.4 and 7.5. The emission rates upon which these calculations are based are presented in Table 7.2. The first case assumed the effect of aerodynamic downwash to be present, an assumption which creates a worst case analysis. The second case assumes that aerodynamic downwash does not occur. The numbering system for the control alternatives is identical to the systems described in detail in chapter 4.

TABLE 7.4. Estimated Impact of Kraft Pulp Mill Assuming the Occurrence of Aerodynamic Downwash (1000 ton per day kraft pulp mill)

TOTAL REDUCED SULFUR (as H_2S)

Control Alternative	Averaging Time	Maximum Combined Concentration ($\mu g/m^3$)	Contribution of Each Source ($\mu g/m^3$)				
			RF	SDT	LK	BLO	BSW
1	10 sec.	~1400	~600	~300	Neg.	Neg.	~500
	1 hr.	185	80	40	Neg.	Neg.	65
	24 hr.	44	20	7	Neg.	Neg.	17
2	10 sec.	225	~190	~35	Neg.	-	-
	1 hr.	30	25	5	Neg.	-	-
	24 hr.	7	6	1	Neg.	-	-
3	10 sec.	225	~190	~35	Neg.	-	-
	1 hr.	30	25	5	Neg.	-	-
	24 hr.	7	6	1	Neg.	-	-
4	10 sec.	225	~190	~35	Neg.	-	-
	1 hr.	30	25	5	Neg.	-	-
	24 hr.	7	6	1	Neg.	-	-
5	10 sec.	225	~190	~35	Neg.	-	-
	1 hr.	30	25	5	Neg.	-	-
	24 hr.	7	6	1	Neg.	-	-

TABLE 7-4 (continued)

PARTICULATE MATTER

Control Alternative	Averaging Time	Maximum Combined Concentration ($\mu g/m^3$)	Contribution of Each Source ($\mu g/m^3$) RF	SDT	LK
1	24 hr.	180	170	10	Neg.
	annual	60	44	12	4
2	24 hr.	91	85	6	Neg.
	annual	31	22	7	2
3	24 hr.	91	85	6	Neg.
	annual	31	22	7	2
4	24 hr.	91	85	6	Neg.
	annual	30	22	7	1
5	24 hr.	91	85	6	Neg.
	annual	30	22	7	1

Note: RF = Recovery Furnace
SDT = Smelt Dissolving Tank
LK = Lime Kiln
BLO = Black Liquor Oxidation Tank
BSW = Brown Stock Washer System
Neg. = Negligible

TABLE 7.5. ESTIMATED IMPACT OF KRAFT PULP MILL EMISSIONS UNDER NON-DOWNWASH ASSUMPTION*
(1000 ton per day kraft pulp mill)

TOTAL REDUCED SULFUR (As H_2S)

Control Alternative	Averaging Time	Maximum Combined Concentration ($\mu g/m^3$)	Contribution of Each Source ($\mu g/m^3$)				
			RF	SDT	LK	BLO	BSW
1	10 sec.	~135	Neg.	~5	~10	~70	~50
	1 hr.	18.4	Neg.	0.6	1.4	9.4	7.0
	24 hr.	3.4	Neg.	0.1	0.3	2.1	0.9
2	10 sec.	~15	Neg.	~2	~13	-	-
	1 hr.	1.0	Neg.	0.1	0.9	-	-
	24 hr.	0.2	Neg.	Neg.	0.2	-	-
3	10 sec.	~30	Neg.	~2	~2.8	-	-
	1 hr.	1.9	Neg.	0.1	1.8	-	-
	24 hr.	0.4	Neg.	Neg.	0.4	-	-
4	10 sec.	~30	Neg.	~2	~2.8	-	-
	1 hr.	1.9	Neg.	0.1	1.8	-	-
	24 hr.	0.4	Neg.	Neg.	0.4	-	-
5	10 sec.	~15	Neg.	~2	~13	-	-
	1 hr.	1.0	Neg.	0.1	0.9	-	-
	24 hr.	0.2	Neg.	Neg.	0.2	-	-

TABLE 7.5. (continued)

PARTICULATE MATTER

Control Alternative	Averaging Time	Maximum Combined Concentration ($\mu g/m^3$)	Contribution of Each Source		
			RF	SDT	LK
1	24 hr.	9.7	Neg.	1.8	7.9
	annual	2.2	0.2	0.4	1.6
2	24 hr.	5.1	Neg.	1.1	4.0
	annual	1.1	0.1	0.2	0.8
3	24 hr.	5.1	Neg.	1.1	4.0
	annual	1.1	0.1	0.2	0.8
4	24 hr.	2.5	Neg.	1.1	1.4
	annual	0.6	0.1	0.2	0.3
5	24 hr.	2.5	Neg.	1.1	1.4
	annual	0.6	0.1	0.2	0.3

Note: RF = Recovery Furnace
SDT = Smelt Dissolving Tank
LK = Lime Kiln
BLO = Black Liquor Oxidation Tank
BSW = Brown Stock Washer System
Neg. = Negligible

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*The non-downwash assumption is ficticious in the general layout of the model (Figure 7-1). It is included here since downwash could be eliminated through design of the mill.

Averaging times of 10 seconds, 1-hour, and 24-hours were selected for the TRS calculations, representing short- and long-term exposures. The 10-second average would be considered a "whiff," and applicable to the study of odorous emissions. The one hour average gives an indication of the level of exposure experienced through casual contact, while the 24-hour average shows the level of exposure of a person living near the mill. Particulate matter concentrations were calculated for 24-hour and annual averages. These levels correspond with the averaging periods used for the National Ambient Air Quality Standards (NAAQS).

Dispersion Calculations Assuming Downwash

The diffusion calculations made assuming downwash (Table 7.4) show that TRS emissions from facilities controlled to average State standards level produce an ambient concentration of about 185 $\mu g/m^3$ (1-hour average). This concentration is mainly caused by emissions from three facilities: The recovery furnace, the smelt dissolving tank, and the brown stock washer system. Contributions due to emissions from the lime kiln and black liquor oxidation system are negligible. Application of emission controls under systems 2,3,4, and 5 produce a significant reduction in concentration, and results in a TRS concentration of about 30 $\mu g/m^3$ on an hourly average basis. Since the contribution of the lime kiln is negligible at the maximum point, no change in concentration is perceivable.

Similar results are seen for the dispersion calculations for particulate emissions. Emissions from the baseline control alternative number 1 produce a maximum concentration of about 180 $\mu g/m^3$ (24-hour average). The emissions from the lime kiln contribute only a negligible amount to the total concentration. Application of control systems

2, 3, 4, or 5 produce reductions in concentrations to about 31 and 30 μg/m^3 (24-hour average).

Dispersion Calculations Assuming No Downwash

Under the non-downwash assumption (Table 7.5), emissions from the lime kiln become significant while those from the recovery furnace are considered to have a negligible contribution toward the maximum concentration. Under control system number 1, the maximum TRS concentration is about 18 μg/m^3 (1-hr average). A large part, about 90%, of this total is due to emissions from the black liquor oxidation tank and the brown stock washer system. These two facilities are fully controlled under systems 2, 3, 4, and 5, and the emissions from the lime kiln are significantly reduced. As a result, the TRS concentration under systems 2 and 5, where caustic scrubbing is applied, averages about 1.0 μg/m^3 (1-hour average). Under systems 3 and 4, where TRS emissions from the lime kiln are controlled by applying good process controls, the maximum concentration is about 1.9 μg/m^3 (1-hour average).

Similar results are obtained for emission of particulate matter. The 24-hour average concentration under the baseline system is about 10 μg/m^3, 80 percent of which is due to emissions from the lime kiln. The smelt dissolving tank contributes the remainder; the contribution from the recovery furnace emissions is negligible. Under systems 2 and 3, where emissions are controlled with a 30-inch venturi scrubber, the 24-hour average is about 5 μg/m^3. When an electrostatic precipitator is used in systems 4 and 5, the maximum concentration is further reduced to about 2.5 μg/m^3.

7.1.2 Secondary Impacts

Secondary impacts on air quality will arise as a result of the electrical requirements of certain control techniques that are used to control kraft mill emissions. Additional emissions of particulate matter, NO_x, and SO_2 from the coal-fired power plant supplying the electrical energy can be anticipated. Based on the new source performance standards for coal-fired power plants, promulgated in the FEDERAL REGISTER on December 23, 1971 (36 FR 24876), the additional emissions can be estimated at 0.1 lb of particulate matter, 0.7 lb of NO_x, and 1.2 lb of SO_2 per 10^6 Btu produced. The amount of additional pollutant emissions therefore are small when compared with the large reductions in mass emissions achieved by implementation of the various alternative control systems.

An additional adverse secondary air impact that must be considered is the emission of SO_2, CO, and NO_x that may be generated as a by-product of the incineration process in the recovery furnace, lime kiln, or separate incinerator. The incremental emissions of these pollutants due to the use of an alternative control system to meet the proposed standards are small.

7.2 WATER POLLUTION IMPACT

No additional liquid wastes will require treatment or disposal as a result of the implementation of any of the alternative systems. Slurries from wet bottom electrostatic precipitators on recovery furnaces and scrubbing water from scrubbers on smelt dissolving tanks are recycled to the process. Scrubbing water and lime mud wash water effluents from the lime kiln system are normally recycled to the causticizing system for chemical recovery. Incineration, the primary means of controlling TRS, does not generate any liquid wastes.

The Agency promulgated water effluent limitations for existing sources in the pulp and paper industry on February 19, 1976 (41 FR 7662). The 1983 standards for new and existing sources were proposed at the same time. For new sources, the proposed standards limit discharge of wastes to the level achievable with "best available demonstrated technology." The use of any of the alternative systems under consideration for control of TRS and particulate emissions from kraft pulp mills will have no effect on the ability of the kraft pulping industry to meet the water effluent guidelines.

7.3 SOLID WASTE IMPACT

The only control devices under consideration that would collect particulates as a dry mass are dry-bottom electrostatic precipitators operating on a recovery furnace or lime kiln. The dry particulate matter from the recovery furnace is primarily Na_2SO_4, which would be reused by dissolving it back into the black liquor and returning it to the furnace for reduction to Na_2S. The sodium salts, calcium carbonate, and calcium oxide collected from the lime kiln emissions can similarly be returned to the system in the causticizing unit. Therefore, no solid waste will require additional handling and disposal as a result of the use of any of the alternative control systems.

A secondary impact concerning solid waste may be caused when a caustic scrubber is used to control lime kiln emissions. If the mill at which the control system is applied cannot accept the added sodium in the form of caustic due to total mill chemical balance, some sodium waste may have to be removed and disposed of. This is not expected to cause a significant impact on land disposal.

7.4 NOISE AND RADIATION IMPACT

Any increases in noise levels that may arise as a result of the proposed standards have not been quantified. It is assumed that any increases are negligible when compared to the existing levels at presently operating mills. There are no known or anticipated impacts resulting from any increases in radiation levels at kraft pulp mills.

7.5 ENERGY IMPACT

The energy requirements associated with the various control techniques are presented in Table 7.6. The control techniques which correspond to three levels of control - economic recovery level, average state standards level, and the level required by the proposed standards - are identified. Where more than one technique may be considered, all alternatives are listed. The incremental energy referenced to the economic recovery level is calculated for both the state standards level and the proposed new source standards level. This calculation shows the energy that is attributable only to control of pollutant emissions. The increase in energy required by the new source standards above that required by the state standards is also presented in terms of 10^6 Btu per

Table 7-6. ENERGY IMPACT (1000-ton-per-day kraft pulp mill)

	Affected Facility	Control Technique			Incremental Energy (Referenced to Economic Recovery Level)						Increase in Total Energy NSPS vs. State Standard Level (10⁶ Btu/day)	Increase in Fuel NSPS vs. State Standard Level (Bbl #6 Fuel Oil/day)	Increase in Coal NSPS vs. State Standard Level (Tons Bitum. Steam Coal/day)
					State Standard			NSPS					
		Economic Recovery Level	Average State Standard Level	New Source Performance Standard	Fuel Requirement (10^6 Btu/day)	Electrical Requirement (kwhr/day)	Total (10^6 Btu/day)	Fuel Requirement (10^6 Btu/day)	Electrical Requirement (kwhr/day)	Total (10^6 Btu/day)			
PARTICULATE	Recovery Furnace	99.0% ESP	99.0% ESP	99.5% ESP	0	0	0	0	0	0	0	0	0
	Smelt Tank	Demister	Scrubber	Scrubber	0	2300	24.7	0	2300	24.7	0	0	0
	Lime Kiln	Scrubber	15" Venturi scrubber	30" Venturi scrubber	0	0	0	0	5100	51.9	51.9	8.2	2.4
				ESP	-	-	-	440	0	440	440	69.4	19.1
TRS	Digester System	None	Incineration	Incineration	0	250	2.7	0	250	2.7	0	0	0
	Mul. Effect Evaporators	None	Incineration	Incineration	INCLUDED IN DIGESTER SYSTEM								
	Brown Stock Washers	None	None	Incineration	0	0	0	20	200	23	23	13.6	1.0
	Black Liq. Ox. System	None	None	Incineration	0	0	0	180	610	186	186	29.3	8.1
	Recovery Furnace	None	Process controls	Non-contact evaporator	1090	0	1090	1090	0	1090	0	0	0
		None	Process controls	Black Liq. oxidation	0	0	0	0	12,100	123	123	19.4	5.3
	Smelt Tank	None	None	Process controls	0	0	0	0	0	0	0	0	0
	Lime Kiln	None	Process controls	p.c. & caustic addition	0	0	0	135	0	135	135	21.3	5.8
	Condensate Stripper	None	Incineration	Incineration	0	35	0.3	0	35	0.3	0	0	0

day, number of barrels of #6 fuel oil, and tons of bituminous-high volatile C steam coal required per day.

By combining the total incremental requirements, the amount of energy attributable to each control system can be determined:

System	Increase in Energy 10^6 Btu/day	 BBl. of Oil/Day	 Ton Coal/Day
1	0	0	0
2	518.9	81.9	22.5
3	518.9	81.9	22.5
4	907.0	143.0	39.4
5	945.0	149.1	41.1

Compared to the baseline system number 1, the incremental values are greatest for systems 4 and 5. This is directly attributable to the added fuel requirement of a separate incinerator that is needed when an ESP is used to control particulate emissions from the lime kiln. There is no increase between systems 2 and 3 since it is assumed that there is no energy requirement attributable to the addition of caustic to the scrubber water. The impact of these energy requirements on the operating costs ($ per ton) for each alternative control system is discussed in Chapter 8.

The total energy required by an average 1000-ton-per-day mill is about 505 x 10^6 Btu per hour for process fossil fuel and electrical requirements including particulate control to the process recovery level. This does not include the energy produced by the combustion of the black liquor in the recovery furnace. Compared to this baseline the percent of this total that would be required by the alternative control systems to meet the proposed standards ranges from 4.3 percent for systems 2 and 3 to 7.9 percent for system 5. The estimated energy that would be required to control all new, modified, and replaced affected facilities at kraft pulp mills constructed during the five-year period through 1980 to comply with the proposed standards is about 1,440,000 barrels of Number 6 fuel oil per year in 1980 (about 9.2×10^{12} Btu per year).

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

The standards of performance will require the installation of additional equipment over that now required by State standards. This will require the additional use of steel and other resources. This commitment of resources is small compared to the national usage of each resource. Much of these resources will ultimately be salvaged and recycled. There are not expected to be significant amounts of land resources required to install control equipment because most control systems are located on buildings and if not, require a relatively small amount of space. Therefore, the commitment of land resources for siting additional control devices is expected to be minor.

The use of sodium hydroxide for the lime kiln scrubber to remove TRS will slightly increase the usage of this commodity which reportedly is now in tight supply. The amount of caustic used by the industry as required by the proposed standard is small compared to the total amount normally used at kraft mills and is minor when compared to the amount of caustic used on a national level. The caustic is recycled within the mill complex; therefore, only a small amount of make-up caustic needs to be added as a result of the standard.

The proposed standards will require the increased usage of energy which is a scarce resource to operate emission control devices. This energy will not be retrievable but will result in the control of significant quantities of TRS and particulate matter. Compared to the total amount of energy consumed in the United States, the amount of energy needed to operate these control devices is small.

7.6.2 Environmental Impact of Delayed Standards

Delay of the proposed standards for kraft pulp mills will have major negative environmental effects on emissions of TRS and particulate matter to the atmosphere and minor positive impacts on water, land, and energy. There are no new technologies presently being developed for control of emissions from kraft pulp mills which would significantly reduce emissions compared to the levels of best demonstrated technology, considering costs, that are currently available. Therefore, there is no reason why the standard should be delayed because of new technology for the facilities affected by the proposed standards.

One potential source of TRS emissions that has not been regulated because control technology and emission measurement methodology have not been identified is the water treatment ponds at kraft mills. The Agency is further investigating this potential source and will take action if the investigation shows that it is a significant source of TRS emissions and there is available technology to control it. This study is likely to take two years. If the standard is delayed until this potential source is investigated, it will result in the emission of 6.8 million pounds of TRS, 14.2 million pounds of particulate matter in the two-year period, that would have been controlled by the proposed standards. In addition, this source could be amended to the kraft mill regulation at a later date if it is determined to be necessary. Therefore, there appears to be no valid reasons to delay the kraft mill standard.

7.6.3 Environmental Impact of No Standard

Based on the growth projections presented in Chapter 8, the adverse environmental impact of no standard is summarized in Table 7.7. Since there are little adverse water pollution and solid waste impacts, and only moderate energy consumption impacts associated with each of the alternative emission control systems which could serve as a basis for the standards, not setting standards presents little trade off of potentially adverse impacts in these areas against the resulting adverse impact on air quality.

Table 7-7. ENVIRONMENTAL IMPACT OF NO STANDARD
A. IMPACT DUE TO NEW KRAFT MILLS AND CAPACITY ADDITIONS AT EXISTING KRAFT MILLS

Year	Kraft Mill Capacity Affected by NSPS (1000 T/yr)		NATIONWIDE EMISSIONS (10^6 lbs/yr)																	
			PARTICULATE					TRS					REDUCTION COMPARED TO ALTERNATIVE 1							
			Alternative					Alternative					Particulate				TRS			
	Yearly Increase	Cumulative	1	2	3	4	5	1	2	3	4	5	2	3	4	5	2	3	4	5
1976	1128	1128	6.2	3.2	3.2	2.8	2.8	1.5	.3	.3	.3	.3	3	3	3.4	3.4	1.2	1.2	1.2	1.2
1977	943	2071	11.4	5.8	5.8	5.1	5.1	2.7	.5	.6	.6	.5	5.6	5.6	6.3	6.3	2.2	2.1	2.1	2.2
1978	982	3053	16.8	8.5	8.5	7.5	7.5	4.0	.8	.8	.8	.8	8.3	8.3	9.3	9.3	3.2	3.2	3.2	3.2
1979	1385	4438	24.4	12.4	12.4	11	11	5.8	1.1	1.2	1.2	1.1	12	12	13.4	13.4	4.7	4.6	4.6	4.7
1980	983	5421	29.8	15.2	15.2	13.4	13.4	7.0	1.4	1.5	1.5	1.4	14.6	14.6	16.4	16.4	5.6	5.5	5.5	5.6
Total Cumulative	5421	5421	88.6	45.1	45.1	39.8	39.8	21.0	4.1	4.4	4.4	4.1	43.5	43.5	48.8	48.8	16.9	16.6	16.6	16.9

Table 7-7 (cont.). ENVIRONMENTAL IMPACT OF NO STANDARD
B. IMPACT DUE TO REPLACEMENT OF EXISTING CAPACITY

	CUMULATIVE EMISSION REDUCTION (10^6 lbs/year)							
YEAR	PARTICULATE				TRS			
	ALTERNATIVE SYSTEM NUMBER				ALTERNATIVE SYSTEM NUMBER			
	2	3	4	5	2	3	4	5
1976	2.3	2.2	2.2	2.3	4.3	4.3	4.7	4.7
1977	4.6	4.4	4.4	4.6	8.6	8.6	9.4	9.4
1978	6.9	6.6	6.6	6.9	12.9	12.9	14.1	14.1
1979	9.2	8.8	8.8	9.2	17.2	17.2	18.8	18.8
1980	11.5	11.0	11.0	11.5	21.5	21.5	23.5	23.5

References

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2. Memo from Phillip L. Youngblood, Transport Simulation Section, MDAD to Jack R. Farmer, Chief of Standards Development Branch, ESED, September 26, 1975.

3. Thomas, D.L., "High Grade for Paper," Barron's, December 11, 1972, p. 3.

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7. Environmental Protection Agency, Effluent Guidelines and Standards: Pulp, Paper, and Paperboard Point Source Category, Federal Register (41 FR 7662), February 19, 1976.

8. Roberson, James E., "Energy and Air Emissions in the Pulp and Paper Industry," J.E. Sirrine Company (not published).

8. ECONOMIC IMPACT

Chapter 8 contains 4 sections. The industry is characterized in section one. Several industry aspects are discussed there. These include geographic distribution, integration and concentration, international influence, demand determinants, supply determinants, and projected industry growth.

In the second section, control costs and cost effectiveness for alternative TRS and particulate control systems are developed and described. Included are costs for 7 of the designated facilities, 4 mill sizes, and 2 recovery furnace configurations. Both new and existing mill situations are examined..

Section three briefly describes other cost considerations and their impact on the economic analysis of TRS and particulate control.

In the final section of Chapter 8, the economic impact of alternative TRS and particulate controls is analyzed. Included is an assessment of absolute and relative control cost magnitudes, price demand elasticity, and simulated return on investment impacts. Analyses are conducted for new, modified, and reconstructed sources.

The major finding of Chapter 8 is the economic impact of each considered alternative is small. In other words, New Source Performance Standards (NSPS) should not preclude construction of new, modified, and reconstructed designated facilities. Small control costs, inelastic price demand elasticity, and small simulated return on investment impacts support the major finding of Chapter 8.

8.1 INDUSTRY CHARACTERIZATION

8.1.1 Geographic Distribution

As of December 1975, there were 56 firms operating about 120 kraft pulping mills in 28 states. Most U.S. kraft pulping mills and mill capacity is found in the South. Alabama, Georgia, and Louisiana are the leaders. Alabama has 13 mills and 10 percent of U.S. mill capacity. Georgia has 11 mills and 13 percent of U.S. mill capacity. And Louisiana has 11 mills and 11 percent of U.S. capacity. Over the past 20 years, growth in the kraft pulping industry has occurred mainly in the South.[1] However, recent 1974, current 1975, and planned(1976 and later) modifications to existing mills as well as plans for new mills are found in all sections of the country.[2]

8.1.2 Integration and Concentration

Only about 1/3 of the 56 firms are producers of pulp, paper, and/or paperboard exclusively. The others are engaged in a wide variety of activities. The activities include chemical manufacture, detergent production, magazine publishing, land development, and can production. The degree of dependency on kraft pulping and related activities varies among these horizontally integrated firms. Whereas International Paper Company derived 55.6 percent of their 1974 sales from pulp, paper, and paperboard production; Ethyl Corporation derived 11 percent of 1974 sales from pulp and paper operations.

Besides being horizontally integrated, the U.S. kraft pulping industry is highly concentrated. The 6 largest firms in terms of mill capacity account for 40 percent of U.S. kraft pulp capacity. The 10 largest account for 56 percent of U.S. kraft pulp capacity.

Vertical integration is another characteristic of the U.S. kraft pulping industry. Only 41 U.S. kraft pulping mills are listed in the directory of world market pulp producers. The most prevalent kraft grade listed is bleached hardwood followed closely by bleached softwood. Moreover, appearance in the directory does not mean the mills' pulp cannot be used captively. When available, pulp for market is produced at the designated mills. Really, nearly all kraft pulp (about 90 percent) produced in the U.S. is not marketed; but is used captively.[3] In fact, 109 kraft pulping mills also have facilities at the same location for producing paper and paperboard. However, these mills cannot always satisfy the kraft pulping requirements of the paper and paperboard facilities. Often times, intracompany transfers from other U.S. and Canadian mills are required to fill the kraft pulping voids.

8.1.3 International Influence

The U.S. kraft pulping industry is not devoid of foreign influence. Pulp, paper, and paperboard production in other countries, especially Canada, has a pronounced influence on U.S. kraft pulping firms and trade balances. Although the U.S. is the world's largest producer of kraft pulp and the fourth leading exporter (behind Canada, Sweden, and Finland), the U.S. has been a net importer of kraft pulp. Over 90 percent of the kraft pulp imported to the U.S. comes from Canada. This is not surprising in view of the earlier statement about intracompany transfers and the fact that a third of the U.S. kraft pulp producers have kraft pulping facilities in Canada.

The aforementioned industry characterization statements were derived primarily from Appendix E and Tables 8-1 and 8-2. Appendix E displays

Table 8-1. SUMMARY INDUSTRY STATISTICS: FIRMS-MILL NUMBER AND CAPACITY DISTRIBUTION

Firm	# U.S. Mills	% U.S. Total	Capacity U.S. Mills	% of U.S. Total
Allied Paper, Inc. (sub. of SCM)	1	1	490	<1
Alton Box Board Co.	1	1	650	<1
American Can Co.	2	2	1,240	1
Appleton Papers, Inc. (Div. of NCR)	1	1	180	negligible
Boise Cascade Corp.	5	4	3,790	4
Bowater, Inc.	2	2	1,500	1
Brown Co.	1	1	700	<1
Champion International	3	3	2,680	3
Chesapeake Corp. of Va.	1	1	1,150	1
Consolidated Papers, Inc.	1	1	395	negligible
Container Corp. of Amer. (sub. of Marcor)	2	2	2,250	2
Continental Can Co.	4	3	3,700	4
Crown Zellerbach	5.5	5	4,216	4
Diamond Int'l Corp.	1	1	425	negligible
Federal Paper Board Co., Inc.	1	1	1,200	1
Fibreboard Corp.	1	1	450	negligible
Georgia-Pacific Corp.	4	3	5,520	5
Gilman Paper Co.	1	1	1,100	1
P. H. Glatfelter Co.	1	1	500	negligible
Great Northern Nekoosa Corp.	3	3	2,510	2
Green Bay Packaging, Inc.	1	1	650	<1
Gulf States Paper Corp.	2	2	875	<1
Hammermill Paper Co.	2	2	856	<1
Hoerner Waldorf Corp.	2	2	2,150	2
Hudson Paper Co.	1	1	950	<1
ITT Rayonier, Inc.	1	1	1,250	1
Inland Container Corp.	1.5	1	1,213	1

Table 8-1 (Continued). SUMMARY INDUSTRY STATISTICS: FIRMS-MILL NUMBER AND CAPACITY DISTRIBUTION

Firm	# U.S. Mills	% U.S. Total	Capacity U.S. Mills	% of U.S. Total
International Paper Co.	14	12	15,985	14
Interstate Container Corp.	1	1	550	<1
Kimberly-Clark Corp.	1	1	585	<1
Lincoln Pulp & Paper Co. (Div. of Premoid)	1	1	320	<1
Longview Fibre Co.	1	1	1,900	1
Louisiana Pacific Corp.	1	1	700	<1
MacMillan Bloedel Ltd.	1	1	925	<1
Mead Corp.	4	3	3,128	4
Mosinee Paper Corp.	1	1	175	<1
Olin Kraft, Inc.	1	1	1,150	1
Owens-Illinois, Inc.	2	2	1,775	2
Oxford Paper (Div. Ethyl Corp.)	1	1	585	<1
Packaging Corp. of Amer. (A Tenneco Co.)	1	1	775	<1
Penntech Papers, Inc.	1	1	180	negligible
Pineville Kraft Corp.	1	1	880	<1
Potlatch Corp.	2	2	1,350	1
Procter & Gamble Co.	1	1	900	<1
St. Joe Paper Co.	1	1	1,300	1
St. Regis Paper Co.	4	3	5,381	5
Scott Paper Co.	3.5	3	2,700	3
Simpson Lee Paper Co.	1.5	1	760	<1
Southland Paper Mills, Inc.	2	2	900	<1
Southwest Forest Industries	1	1	600	<1
South Carolina Industries (79% owned by Stone Container Corp.)	1	1	675	<1
Temple-Eastex, Inc. (sub. of Time, Inc.)	1	1	1,300	1
Union Camp Corp.	3	3	4,980	5
Western Kraft	3	3	1,370	1
Westvaco Corp.	4	3	4,254	5
Weyerhauser Co.	7	6	6,195	6
Totals 56	119		105,567	

Table 8-2. SUMMARY INDUSTRY STATISTICS: STATES-MILL NUMBER AND CAPACITY DISTRIBUTION

State	Number of Mills	% of U.S. Total	State Mill Capacity	% of U.S. Total
Alabama	13	11	10,280	10
Arizona	1	1	600	1
Arkansas	6	5	5,430	5
California	4	3	1,910	2
Florida	8	7	9,260	9
Georgia	11	9	13,505	13
Idaho	1	1	950	1
Kentucky	2	2	920	1
Louisiana	11	9	11,655	11
Maine	6	5	3,950	4
Maryland	1	1	665	1
Michigan	2	2	825	1
Minnesota	2	2	865	1
Mississippi	4	3	4,707	4
Montana	1	1	1,200	1
New Hampshire	1	1	700	1
New York	1	1	590	1
North Carolina	5	4	5,650	5
Ohio	1	1	540	1
Oklahoma	1	1	1,600	2
Oregon	7	6	5,906	6
Pennsylvania	3	3	860	1
South Carolina	4	3	5,494	5
Tennessee	2	2	1,275	1
Texas	6	5	4,570	4
Virginia	4	3	4,550	4
Washington	7	6	5,854	6
Wisconsin	4	3	1,256	1
Totals 28	119		105,567	

kraft mill characteristics. Table 8-1 exhibits mill number and capacity distribution by firm. Table 8-2 exhibits mill number and capacity distribution by state.

8.1.4 Demand Determinants

Following traditional microeconomic theory, tastes, other demands, income, and prices are the determinants of kraft pulp demand.

8.1.4.1 Tastes

Tastes are an important; albeit for forecast purposes, an elusive demand determinant. The main taste factor influencing the demand for kraft pulp is strength. The strength of kraft pulp is superior to that of other pulps (ex. other wood and nonwood pulps). Data are available which is consistent with, but by no means proves the role of superior strength in kraft pulp demand determination. Figure 8.1 reveals that kraft pulp consumption is increasing relative to that of other wood pulps.

Taste can also influence the particular grade of kraft which is desired. Kraft pulp comes in unbleached, semi-bleached, bleached, alpha, and dissolving grades. We don't know the exact role of tastes in selecting a particular grade. However, bleached and unbleached kraft pulps, as revealed in Figure 8.2, are the dominant grades. They account for over 90 percent of total kraft pulp consumption.

8.1.4.2 Other Demands

Other demands include those expressed desires and abilities to purchase kraft pulp complements (ex. bleached kraft pulp and paper) and substitutes (ex. bagasse and plastic).

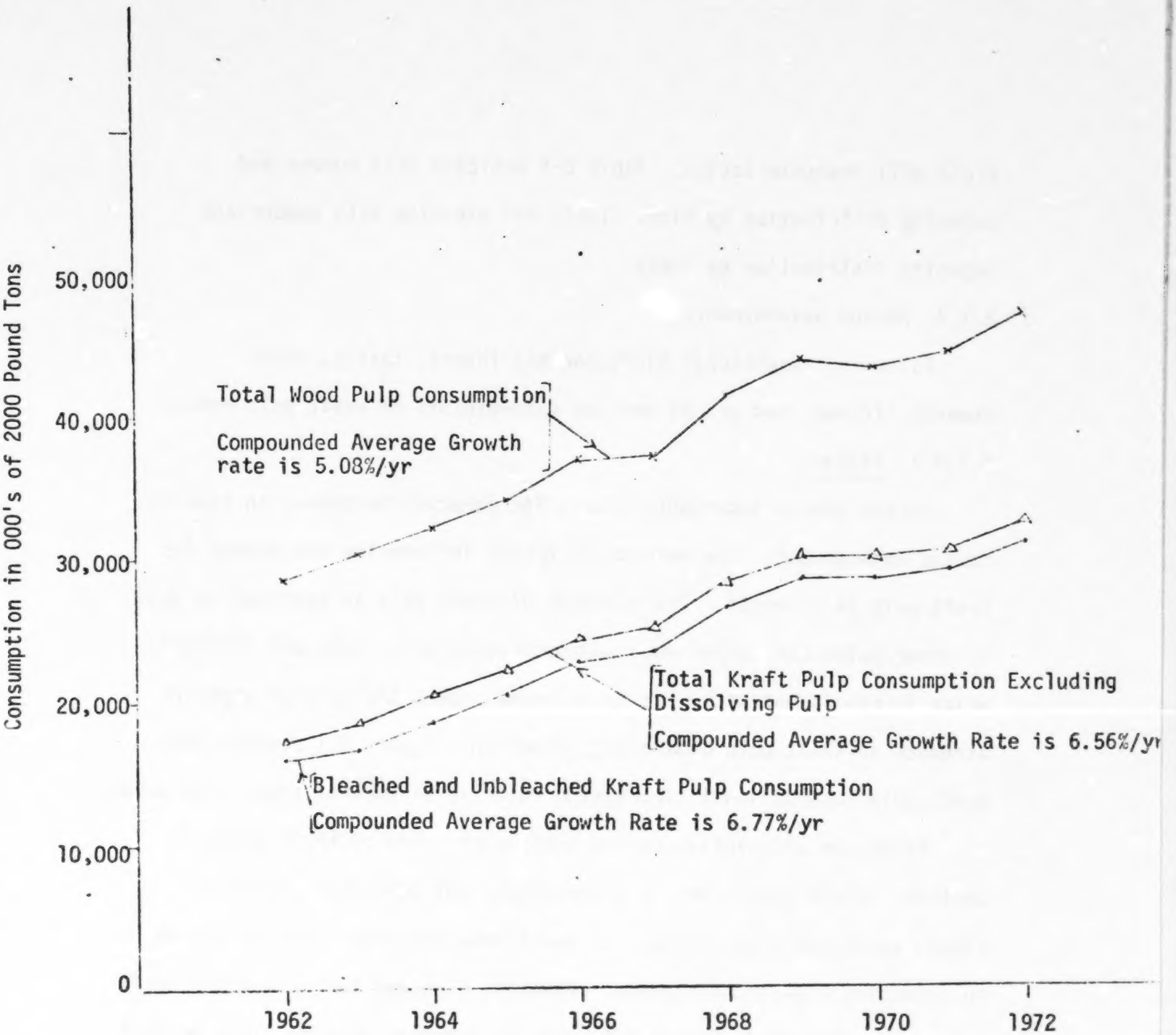

Figure 8-1. Wood, Total Kraft, and Bleached and Unbleached Kraft Pulp Consumption

Source: API, Statistics of Paper and Paperboard 1973, p. 43

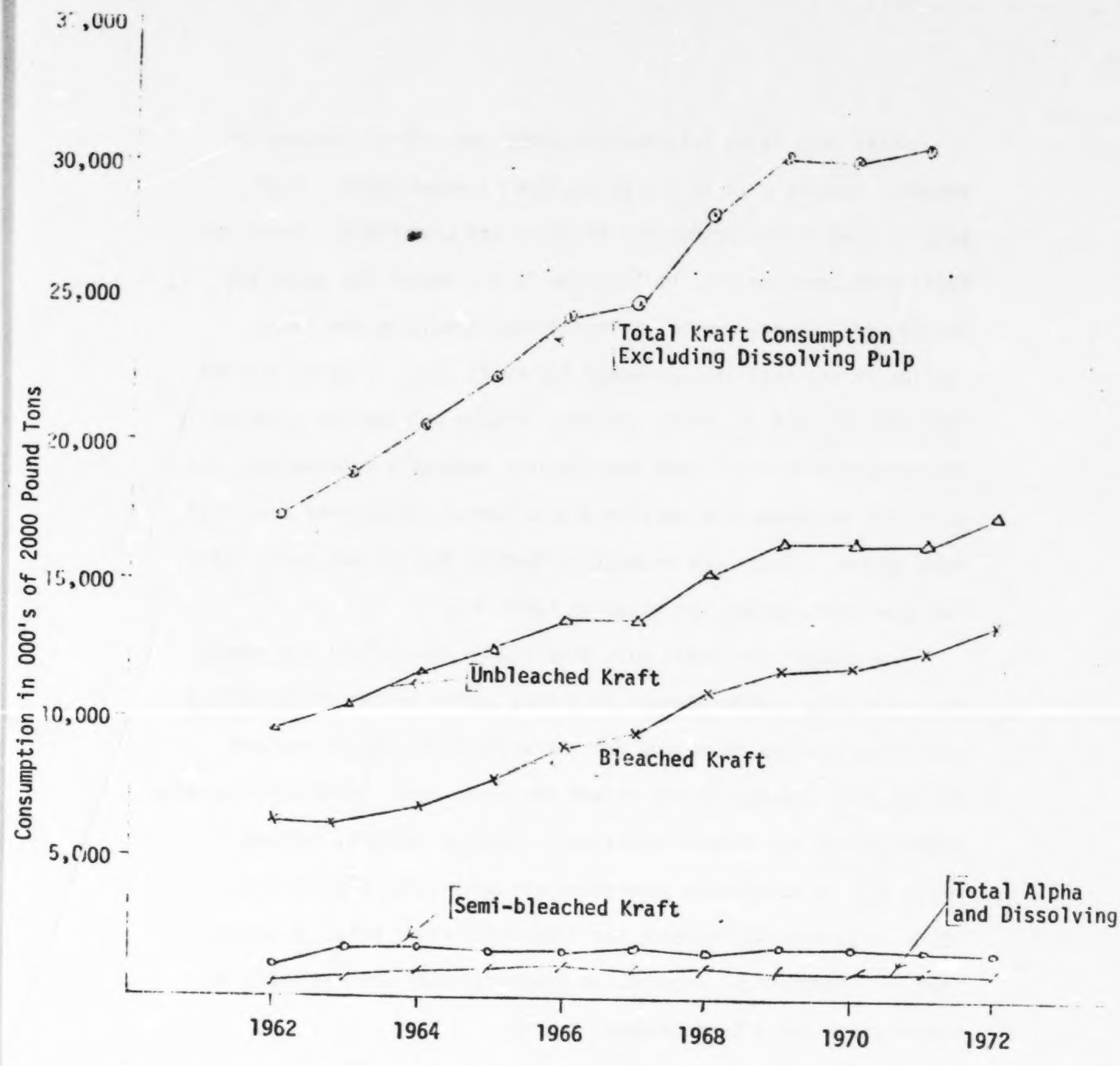

Figure 8-2. Consumption of Various Kraft Pulp Grades

The dissolving Pulp figures, although small, are not distinguished as coming from Kraft or Sulfite mills.

Data Sources: API, Statistics of Paper and Paperboard p.43, 1973
Chemical Economics Handbook, Woodpulp Consumption p.2261180B

Kraft pulp is an intermediate good; not a final consumption product, but one used in the production of other goods. Kraft pulp is used in the production of paper and paperboard. These are kraft pulp complements. An increase in the demand for paper and paperboard, ceteris paribus (other things remaining the same), implies an increase in the demand for kraft pulp. Figures 8.3 and Table 8-3 support the above remarks. Figure 8.3 depicts graphically the movements of kraft pulp consumption, wood pulp consumption, and paper and paperboard production with alternative observed levels of real income. Historical production figures for various pulp, paper, and paperboard grades are given in Table 8-3.

The demands for kraft pulp substitutes also affect the demand for kraft pulp. With changes in tastes and/or prices of substitute goods come changes in demand for the kraft pulp substitutes and subsequently changes in the demand for kraft pulp. With significantly higher prices for plastic containers, ceteris paribus, consumers would tend to substitute paperboard containers for plastic ones, which in turn would increase the demand for kraft pulp. Although true in a theoretical context, no empirical data are available to substantiate the aforementioned remarks.

8.1.4.3 Income

Income along with prices affects purchasing power. Through the purchasing power influence, income is a demand determinant for kraft pulp. The exact manner in which income plays its demand determining role is not known. When the level of income in the aggregate increases, it may mean more people have the same amount

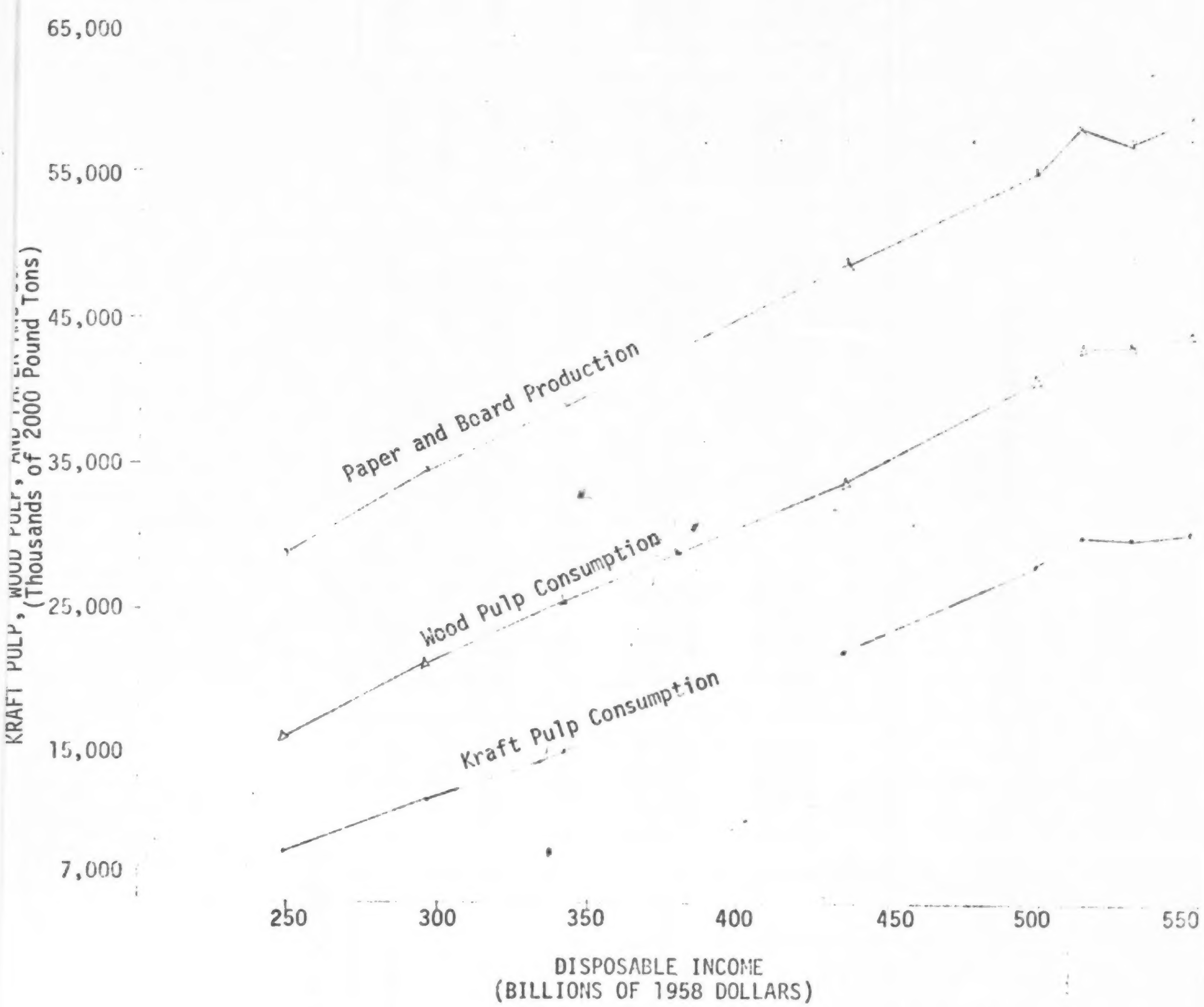

Figure 8-3. Disposable Income and Kraft Pulp; Wood Pulp; and Paper & Board Consumptio

Data Sources: Statistics of Paper and Paperboard, 1973, API, pp. 60-61.
Statistical Abstract of the United States, 1972, Dept. of Commerce, p. 317.

Table 8-3. PULP, PAPER, AND PAPERBOARD PRODUCTION
(in short tons)

	1965	1970	1971	1972	1973	1974
Pulp (in tons)						
Unbleached kraft	12,698,000	16,217,000	16,309,000	17,792,000	18,164,000	16,982,000
Bleached kraft	7,280,000	11,348,000	11,685,000	12,460,000	12,848,000	13,938,000
Semi-bleached kraft	1,531,000	1,906,000	1,557,000	1,574,000	1,826,000	1,422,000
Paper						
Printing, writing & related	11,321,518	14,368,527	14,504,607	15,705,240	16,828,249	16,826,820
Packaging & industrial converting	4,978,556	5,446,050	5,457,576	5,705,891	5,723,102	5,935,700
Tissue & other machine-creped	2,886,968	3,594,500	3,875,657	4,024,207	3,984,598	3,908,907
Paperboard						
Solid woodpulp furnish (ex. corrugating medium, mill carton)	12,743,997	18,496,113	19,157,527	21,126,635	21,527,339	21,411,119
Combination furnish (ex. linerboard)	8,089,588	6,968,950	6,962,971	7,395,326	7,932,196	7,310,660
Wet machine board	143,872	139,055	137,825	147,914	149,035	134,928
Construction paper and board	3,915,381	4,316,198	5,351,863	5,351,863	5,539,319	5,092,944

Data Source: American Paper Institute.

of income; some people have more income; or more people have more income.

Real personal disposable income is positively correlated with kraft pulp consumption, wood pulp consumption, and paper and paperboard consumption. However, the slope of the implicit functional relationship is not as great for kraft pulp. This observation is displayed in Figure 8.3. The smaller implied response of kraft pulp consumption to disposable income changes (e.g. smaller slope) could mean the prices of kraft pulp and other goods have a more active role in kraft pulp demand determinations.

8.1.4.4 Prices

The role of prices as demand determinants can be described in terms of elasticity. Price elasticity of demand is a measure of the responsiveness of quantity demanded to price changes, ceteris paribus. It can be expressed as the percentage change in quantity demanded divided by percentage change in price. The direct price elasticity is probably less than 1.0 for kraft pulp. The limited uses of kraft pulp; the availability of only a few close substitutes; and the small portion of final demand product or service value accounted for by the price of kraft pulp support the belief of relatively inelastic demand. In addition, one expert has indicated the coefficient of direct price elasticity is about 0.5 for domestic wood pulp.[4] Small increases in the price of kraft pulp, everything else remaining the same will not decrease the total revenue from kraft pulp sales. Though no quantitative indirect (cross price) elasticity estimates are available, the prices of kraft pulp substitutes (recycled paper, non-wood pulps, and often times other wood pulps) and complements (bleaching chemicals, paper, paperboard), do not appear to measurably affect the quantity of kraft pulp demanded.

8.1.5 Supply Determinants

The determinants of kraft pulp supply are the production, expenditure, and revenue functions of kraft pulp suppliers.

8.1.5.1 Production

The kraft pulping production function has several advantages. The process can be used with resinouswoods, hardwoods, softwoods, and bark free mill residue. Hence, the wood inputs are readily available. For a chemical pulping process, kraft has a high yield per ton of pulp wood input. In addition, the process yields the side products of tall oil and turpentine from resinous woods inputs. However, kraft pulp is more difficult to bleach than other pulps (i.e., sulfite). Also, the air pollution problems are more serious.

8.1.5.2 Expenditures

Wood, chemicals, labor, energy, and capital are expenditures of kraft pulping.

°Wood - Besides increased demands for all pulp producers, pulpwood faces increased demands from the recreation area, building construction, and home furniture sectors. With the higher pulpwood prices, kraft pulp producers have been encouraged to use more bark free mill residue as well as tree tops and limbs.

° Chemicals - Sodium carbonate, sodium sulfate, sodium sulfide, sodium hydroxide, and calcium oxide are chemicals used in the kraft pulping process. With improved sulfur recovery techniques for pollution control, consumption of sodium sulfate has been declining. The other chemicals are generally currently in short supply. But, new chemical plants coming on stream in the next two years should relieve much of the supply problem.

° Labor - Labor expenses have moved with improved productivity in the pulp, paper, and board industry. Productivity and wage data is not available for kraft pulping alone.

° Energy - Higher fuels and electricity cost have induced energy conservation and trends toward self sufficiency. Expenditures in energy conservation and self sufficiency projects and subsequent energy savings have recently been evidenced.[5]

° Capital - Capital spending for the pulp and paper industry has increased rapidly over the last decade. To finance these expenditures, debt financing has been used extensively. For the pulp, paper, and board industry long term debt as a percent of the total capital structure has increased from about 21 percent to 32 percent.[6] Non-capacity increasing capital expenditures have increased in recent years. These include control of certain air and water effluents along with investments in non-paper industries. Interest rates are currently high and projected to remain so. Profits have historically been quite volatile. With debt financing already extensively utilized, capacity growth displaced by other capital expenditures, interest rates high, profits historically volatile; less costly means of finance, less capital spending, and less capital demanding ways to expand capacity will be induced.

8.1.5.3 Revenue Function

The revenues of kraft pulp producers have been historically unstable. When the industry expanded, it expanded markedly. With supply increases, prices declined and with inelastic demand so did profits. In the ensuing years, non-price related demand increases (i.e., income increase) occurred leading to higher prices, higher profits, and the inducement for another round of supply expansion. Recently though, prices of pulp have remained high and even increased. (See Table 8-4.) Large additional supply increases are not yet in the construction stages. Perhaps rising factor costs have erased or reduced what would have been extremely high profits at these higher prices. And/or maybe the displacement of capacity expanding investment by other capital expenditures can explain the apparent change in the historically unstable revenue function.

8.1.6 Projected Industry Growth

8.1.6.1 Net Capacity Additions

According to the American Paper Institute (API), the U.S. kraft pulping capacity grew at about 5.5%/yr. from 1956 to 1975. The same source indicates growth will decrease to 2.5%/yr. in the 1976 to 1978 period. However, large capacity additions are currently under consideration for 1979 and 1980. If constructed, the industry will return to a higher growth rate (about 3.4%/yr.).

Table 8-4. PRICES OF KRAFT PULP
(U.S. Delivered; Dollars per Ton of Air Dried Pulp)

		Kraft Pulp Forms			
Year and Quarter		Unbleached	Semibleached	Bleached Softwood	Bleached Hardwood
1972	2nd	130-145	163-164	169-172	146-155
1972	4th	130-145	163-164	169-172	146-155
1973	1st	145-147	158-165*	157-169	155
1973	2nd	N.A.	158-165*	175-185*	157-170*
1973	3rd	167-170	172-180	175-202	157-168-193
1973	4th	193	200	203-210	189-193
1974	1st	N.A.	200	203	193
1974	2nd	N.A.	N.A.	265	255
1974	3rd	315-318*	315-318	325	320
1974	4th	345-360*	337-362	340-372	320-335
1975	1st	345-360*	337-362	340-369	320-335
1975	2nd	345-360*	337-362	340-372	320-335
1975	3rd	345-360*	337-362	340-372	320-335
1975	4th	345-360*	337-362	340-372	320-335

*U.S. and Canadian Prices.

Data Source: Paper Trade Journal, Vance Publishing Co., N.Y.C. and Official Board Markets, Magazine for Industry, Inc., Chicago.

The distribution of projected capacity growth between new and existing plants is unknown. But, the equivalent of thirty-three 500 tpd mills will be needed to meet projected growth and capacity considerations through 1980.

8.1.6.2 Designated Facility Replacement Rate

In addition, industry will have to replace worn-out designated facilities to maintain the existing capital stock. However, whether or not these designated facilities will be replaced in kind or with larger facilities (to meet growth requirements) is not known. Moreover, because of variations in capacity utilization and maintenance, the timing of designated facility replacement is also an unknown.

But, given three assumptions, replacement rates can be projected. First, the estimated average designated facility lives are 25 years for recovery furnaces and smelt dissolving tanks, 22 for digesters and multiple effect evaporators, 35 for lime kilns, 15 for brown stock washers, and 10 years for black liquor oxidation units. Second, the designated facility age is distributed evenly. For example, 1/25 of the recovery furnaces are 25 years old; 1/25 are 24 years old, etc. And third, each of the 119 mills has one set of each designated facility. Then, projected annual replacements would be five sets of digesters, multiple effect evaporators, recovery furnaces, and smelt dissolving tanks. (e.g. 1/25 x 119 = 5; 1/22 x 119 = 5). In addition, there would be 4 sets of lime kilns, 8 brown stock washer systems, and about 11 black liquor oxidation systems replaced annually.

8.2 CONTROL COSTS AND COST EFFECTIVENESS

8.2.1 New Sources

8.2.1.1 Introduction

The purpose of this section is to develop estimates of capital and annualized costs for alternative control systems exemplary of best controls taking into account cost. The cost to achieve various levels of control will be presented for each of the affected facilities for three sizes of kraft mills: 500, 1000, and 1500 tons per day of air dried pulp. Following the presentation of control costs for the individual affected facilities is a section showing the aggregate incremental control costs over requirements for typical state standards. Aggregate incremental control costs will be presented for the four alternative control systems discussed in Chapter 4 for the three sizes of kraft mill models. The cost effectiveness of the alternative control systems will then be discussed.

Throughout this section the terms capital cost and annualized cost are used; therefore, a brief definition is in order. The capital cost includes all the cost items necessary to design, purchase and install the particular device or system. The capital cost includes the purchased cost of the major control device (ESP or scrubber) and auxiliaries such as pumps, fans, and instrumentation; the equipment installation cost including foundations, piping, electrical wiring, and erection; and the cost of engineering, construction overhead, and contingencies. In general offsite costs such as utility facilities are not included. Exceptions or other special factors are pointed out in the discussion of each affected facility. The sources of cost data are given for each control device or system. All costs are in terms of (4th quarter) 1975 dollars.

The annualized cost of a control system is a measure of what it costs the company to own and operate that system. The annualized cost includes direct operating costs such as labor, utilities, and maintenance; and capital related charges such as depreciation, interest, administrative overhead, property taxes, and insurance. The actual costs experienced by different mills can vary considerably. The following values were chosen as typical and should provide a reasonable estimate of the annualized cost of the control systems.

Operating labor is charged at a rate of $8 per hour. Utility rates are:

Electricity - 2¢ per Kwh

Fuel - $1.50 per million BTU

Cooling water - $0.05 per thousand gallons

Process water - $0.25 per thousand gallons

Unless otherwise known from specific operating experience annual maintenance labor and materials are estimated as a percentage of the capital cost. The percentage used is in the range of 2 to 5 percent depending on the severity of the service.

The method used to account for depreciation and interest is through the use of a capital recovery factor. The capital cost of the project is multiplied by the capital recovery factor to give the amount of equal annual payments that would pay for the project plus interest over the life of the equipment. The numerical value of the capital recovery factor depends on the life of the equipment and the interest rate. Unless otherwise noted, the numerical value of the capital recovery factor used in this section is based on 15 year life and 10 percent interest. Other capital related charges are administrative overhead at 2 percent of capital and property tax and insurance at 2 percent of capital. The final item considered is any credit due to value of recovered material. Any credit for recovered material is an offset against the annualized cost of the control device. The basis for valuation of credits is given in the discussion of the applicable affected facility.

8.2.1.2 Unit Cost for the Affected Facilities

The proposed standards of performance cover particulate and total reduced sulfur (TRS) emissions. The cost for controlling the affected facilities which emit particulates are discussed first followed by a discussion of the affected facilities which emit TRS. Three of the affected facilities which emit both particulates and TRS are discussed in each section.

A. Unit Costs for Particulate Sources

a) Direct Contact Recovery Furnace - The direct contact recovery furnace system employs a direct contact evaporator using the hot flue gas from the furnace to evaporate water from the black liquor feed to the furnace. The direct contact evaporator removes some of the particulates from the flue gas. Thus the control device following the direct contact evaporator can be smaller and less expensive than the control device on an indirect contact furnace.

Capital costs, annualized costs, and credits for recovered particulate are shown in Table 8-5 for electrostatic precipitators (ESP) for two different levels of control and for a venturi scrubber. The costs for the first ESP case are based on a study

Table 8-5. CONTROL COSTS FOR DIRECT CONTACT RECOVERY FURNACES

Mill Size, TPD	500	1000	1500
		High Efficiency Precipitator (99.5%)	
Capital Cost ($)	1,440,000	2,560,000	3,660,000
Gross Annualized Cost[a] ($/Yr)	364,000	633,000	895,000
Credits[b] ($/Yr)	(892,000)	(1,784,000)	(2,680,000)
		Medium Efficiency Precipitator (99.0%)	
Capital Cost ($)	1,250,000	2,100,000	2,725,000
Gross Annualized Cost[a] ($/Yr)	316,000	519,000	666,000
Credits[b] ($/Yr)	(890,000)	(1,780,000)	(2,668,000)
		Venturi Scrubber (92%)	
Capital Cost ($)	650,000	1,100,000	1,625,000
Gross Annualized Cost[a], ($/Yr)	420,000	830,000	1,215,000
Credits ($/Yr)	(824,000)	(1,650,000)	(2,480,000)

[a] Gross annualized costs do not include credits.

[b] Credits based on Na_2SO_4 at $50 per ton and 7884 hours operation per year. These credits do not include the recovered material collected by the direct contact evaporator.

done for EPA by the Industrial Gas Cleaning Institute (IGCI).[7] The cost for the second ESP case is an EPA estimate based on the IGCI study, and the venturi costs are based on the Sirrine report.[8] The credits for recovered particulate are calculated assuming that all the particulate is salt cake valued at $50 per ton. Although some of the particulate is Na_2CO_3, it is close in price to salt cake; thus, the assumption that the particulate is all salt cake should not result in a significant difference.

For each of the control devices in Table 8-5, the credits exceed the costs. Since the particulate is a valuable material (mainly salt cake), it is economical to recover the particulate emissions up to some recovery level. Beyond that level the value of the additional particulate recovered is not enough to justify the additional investment; that is, the incremental return on the incremental investment drops below the acceptable level for the individual company. The optimal economic recovery level is very difficult to define, even in this analysis with the two basic design differences in the recovery furnaces.

Furthermore, this analysis focuses on the incremental costs between two levels of control, and thus the optimal recovery level is no longer relevant. What is important is the incremental (net) cost between the high efficiency precipitator and the baseline medium efficiency precipitator required for typical state standards. The incremental control costs for the high efficiency precipiator are presented in Table 8-6. The annualized cost per ton of product is based on production at 90 percent of capacity.

Table 8-6. INCREMENTAL CONTROL COSTS[a] FOR DIRECT CONTACT RECOVERY FURNACES OVER STATE REGULATORY REQUIREMENTS

Mill Size, TPD	500	1000	1500
	High Efficiency Precipitator (99.5%)		
Capital Cost ($)	190,000	460,000	935,000
Annualized Cost[b] ($/Yr)	46,000	110,000	217,000
Annualized Cost per Ton[c] ($/T)	0.280	0.335	0.440

[a] The difference between the high efficiency precipitator and the typical state regulatory requirement (Equivalent to 99.0% efficiency).

[b] The credits have been accounted for in calculating the incremental annualized costs.

[c] Based on 7884 hours of operation per year.

b) Indirect Contact Recovery Furnace - In contrast to the previously discussed recovery furnace, the indirect contact recovery furnace does not have a direct contact evaporator. This results in higher inlet concentrations to the control device. In addition the physical properties of the particulate are somewhat different from the direct contact furnace case. These factors cause the ESP to be larger and more expensive in order to achieve the same exit particulate concentration. Because of the higher particulate inlet concentrations, the credits for recovered particulate appear to be greater for the indirect contact furnace. The fact is that the combination of the direct contact evaporator plus the precipitator collect as much salt cake for the direct contact furnace as the comparable precipitator does for the indirect contact recovery furnace.

The same references were used as the sources of the control costs for this furnace design as for the direct contact recovery furnace. Table 8-7 shows the capital, annualized costs, and credits for two levels of precipitation and one level of venturi scrubber. Table 8-8 shows the incremental costs for the high efficiency precipitator over the medium efficiency precipitator, the latter being the baseline for state regulatory requirements.

c) Smelt Dissolving Tank - Two control alternatives are presented for the smelt dissolving tank. The first is a mesh pad demister. The demister is a very simple and inexpensive device which has been used extensively in the industry. The second alternative is a packed bed scrubber which gives a higher control efficiency than the demister. The costs shown on Table 8-9 for the demister

Table 8-7. CONTROL COSTS FOR INDIRECT CONTACT RECOVERY FURNACES

Mill Size, TPD	500	1000	1500
		High Efficiency Precipitator (99.8%)	
Capital Cost ($)	2,310,000	4,000,000	5,500,000
Gross Annualized Cost[a] ($/Yr)	511,000	879,000	1,210,000
Credits[b] ($/Yr)	(1,754,000)	(3,508,000)	(5,262,000)
		Medium Efficiency Precipitator (99.6%)	
Capital Cost ($)	2,000,000	3,380,000	4,675,000
Gross Annualized Cost[a] ($/Yr)	442,000	743,000	1,030,000
Credits[b] ($/Yr)	(1,752,000)	(3,504,000)	(5,236,000)
		Venturi Scrubber (92%)	
Capital Cost ($)	650,000	1,100,000	1,625,000
Gross Annualized Cost[a] ($/Yr)	420,000	830,000	1,215,000
Credits[b] ($/Yr)	(1,616,000)	(3,232,000)	(4,848,000)

[a] Gross annualized costs do not include credits.

[b] Credits based on Na_2SO_4 at $50/ton and 7884 hours of operation per year. In comparison with the direct contact furnace, the direct contact evaporator itself would recover approximately fifty percent of the total generated emissions, or 50 percent of these credits.

Table 8-8. INCREMENTAL CONTROL COSTS[a] FOR INDIRECT CONTACT RECOVERY FURNACES OVER STATE REGULATORY REQUIREMENTS

Mill Size, TPD	500	1000	1500
	High Efficiency Precipitator (99.8%)		
Capital Costs ($)	310,000	620,000	825,000
Annualized Cost[b] ($/Yr)	67,000	132,000	154,000
Annualized Cost per Ton[c] ($/T)	0.408	0.402	0.304

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[a] The difference between the high efficiency precipitator and the typical state regulatory requirement (equivalent to 99.6% efficiency).

[b] The credits have been accounted for in calculating the incremental annualized costs.

[c] Based on 7884 hours of operation per year.

Table 8-9. CONTROL COSTS FOR SMELT TANK CONTROL SYSTEMS

Mill Size, TPD	500	1000	1500
		Demister System (80%)	
Capital Cost ($)	23,750	28,750	35,000
Gross Annualized Cost[a] ($/Yr)	5,000	5,900	7,030
Credits[b] ($/Yr)	(35,000)	(70,000)	(105,000)
		Scrubber System (96%)	
Capital Cost ($)	87,500	138,000	175,000
Gross Annualized Cost[a] ($/Yr)	24,800	41,600	55,900
Credits[b] ($/Yr)	(42,000)	(84,000)	(128,000)

[a] Gross annualized costs do not include credits.

[b] Credits based on Na_2SO_4 at $50/ton and 7884 hours of operation per year.

are based on the Sirrine report.[9] The cost for the demister includes the mesh pads and a water spray system. Since the pressure drop is low (less than 0.2 inches of water), no fan has been included in the cost estimate. The credit for recovered particulate is based on 80 percent recovery of the uncontrolled emissions. The value of the recovered particulate is calculated on the basis of recovered sodium where the sodium would be made up using salt cake at $50 per ton.

The scrubber system is a packed tower with associated fan, liquid recirculation pump, and controls. Cost data for this type of control system were collected from several operating companies in addition to the information in the Sirrine report.[10] The costs for the scrubber system are shown in Table 8-9. Credits for recovered particulate are calculated in the same manner as for the demister case except that the recovery efficiency is 96 percent.

The incremental control costs for best controls (the 96 percent efficiency scrubber) over typical state regulatory requirements (achievable by the demister) are shown in Table 8-10. These costs are the residuals after deducting for credits.

d) Lime Kiln - Costs for the two basic types of collection devices are examined for control of particulate emissions from the rotary lime kiln, namely venturi scrubbers and electrostatic precipitators. The analysis for these controls is somewhat complicated by the interrelationship of controlling TRS emissions (discussed in the next section).around the lime kiln facility. For example, the use of a precipitator would dictate (for safety reasons)

Table 8-10. INCREMENTAL CONTROL COSTS[a] FOR THE SMELT DISSOLVING TANK OVER STATE REGULATORY REQUIREMENTS

Mill Size, TPD	500	1000	1500
Capital Cost ($)	63,750	109,300	140,000
Annualized Cost[b] ($/Yr)	12,800	21,700	25,870
Annualized Cost per Ton[c] ($/T)	0.078	0.066	0.053

[a] The incremental cost is the difference in cost between the scrubber and the demister system, which is assumed to be acceptable for typical state regulations.

[b] Based on 7884 hours of operation per year.

[c] The credits have been accounted for in calculating the incremental annualized costs.

the application of a separate incinerator for handling TRS noncondensibles from digester and multiple-effect evaporator relief vents. When scrubbers are used to control lime kiln emissions, normally the lime kiln can be the incineration point for these TRS noncondensibles.

Three different control alternatives are examined: (1) a 15-inch pressure drop scrubber, (2) a 30-inch pressure drop scrubber, and (3) a high efficiency electrostatic precipitator equivalent to the 30-inch pressure drop scrubber. The costs for installation and operation of the particulate control devices are based on a study by the Industrial Gas Cleaning Institute.[11] In addition, the costs of a separate incinerator and fuel for destruction of the aforementioned TRS emissions are included in the precipitator costs. The costs for thermal destruction in this manner have been developed from information provided by Rust Engineering.[12] Credits for recovered particulates have been valued on the basis of makeup ground limestone ($CaCO_3$) at $20 per ton. The costs of these scrubbers and the precipitator (with separate incineration) are shown in Table 8-11.

The incremental costs for alternative controls over state requirements (assuming the 15-inch scrubber as an acceptable control device) are shown in Table 8-12. Here, the controls have been identified with alternatives 2, 3, 4, or 5, which are discussed in Section 4.3. The costs in Table 8-12 represent only those costs associated with particulate removal. Alternative 5 will also include a scrubber, which follows the precipitator, for introducing the caustic into the gas stream for TRS absorption service. See Section 8.2.1.2B(g).

Table 8-11. CONTROL COSTS FOR LIME KILNS

Mill Size, TPD	500	1000	1500
High Efficiency Precipitator[a]			
Capital Costs ($)	306,000	442,000	545,000
Gross Annualized Costs ($/Yr)[b]	185,000	329,000	467,000
Credits ($/Yr)[c]	(75,250)	(184,500)	(291,750)
30-Inch Pressure Drop Scrubber			
Capital Costs ($)	119,000	165,000	214,000
Gross Annualized Costs ($/Yr)[b]	73,400	136,400	200,000
Credits ($/Yr)	(75,000)	(184,000)	(291,000)
15-Inch Pressure Drop Scrubber			
Capital Costs ($)	99,000	140,000	178,000
Gross Annualized Costs ($/Yr)[b]	51,300	93,300	134,700
Credits ($/Yr)	(72,500)	(181,000)	(289,000)

[a] Costs for precipitator include separate incinerator and fuel to destroy digester and multiple-effect evaporator TRS noncondensibles.

[b] Gross annualized costs exclude credits.

[c] Credits for recovered particulates are valued as ground $CaCO_3$ at $20 per ton, based on 7884 hours of operation per year.

Table 8-12. INCREMENTAL CONTROL COSTS OVER STATE REQUIREMENTS FOR LIME KILNS[a]

Mill Size, TPD	500	1000	1500
High Efficiency Precipitator (Alternative 4, & 5)			
Capital Costs ($)	207,000	302,000	367,000
Annualized Costs ($/Yr)[b]	131,000	232,200	329,600
Annualized Cost per Ton ($/T)[c]	0.800	0.707	0.670
30-Inch Pressure Drop Scrubber (Alternatives 2 & 3)			
Capital Costs ($)	20,000	25,000	36,000
Annualized Costs ($/Yr)[b]	19,600	40,100	63,300
Annualized Costs per Ton ($/T)	0.120	0.122	0.128

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[a] The baseline for determination of incremental costs is the 15-inch pressure drop scrubber.

[b] Annualized costs are net after credits.

[c] Based on 7884 hours of operation per year.

B. Unit Costs for Total Reduced Sulfur Sources

a) Digesters and Multiple-Effect Evaporators - The vent gas streams from the digesters and the multiple-effect evaporators are similar; that is, small gas volumes but high TRS concentrations. Since it is common practice in the industry to combine and treat the emissions from both affected facilities together, the control costs are presented for a combined treatment system. The two types of control techniques discussed are scrubbing with white liquor and incineration in the lime kiln. One additional variable has an effect on the cost of the control systems. That variable is the type of digester--batch or continuous.

The scrubbing alternative has limited effectiveness because the scrubbing liquor will only absorb some of the TRS compounds. The scrubber system consists of a gas collection and delivery system, a scrubbing tower, and liquid piping. The system is designed to handle the maximum gas flow from the digester system. During periods of low flow, make-up air is used to maintain a constant gas flow rate to the scrubber. One consequence of this design feature is that the cost of this scrubber system is the same for the three model mills. The Sirrine report is the main source of cost data for this system.[13] The costs are presented in Table 8-13.

The second alternative is incineration of the emissions in the lime kiln, another furnace, or boiler. The system consists of the necessary piping and blowers to collect the gas streams, and delivery piping and controls to inject the gases into the incineration point, the lime kiln. A separate incinerator could be used

Table 8-13. CONTROL COSTS FOR THE DIGESTER AND THE MULTIPLE EFFECT EVAPORATORS

Mill Size, TPD	500	1000	1500
		Scrubbing with White Liquor - Batch Digesters	
Capital Cost ($)	57,500	57,500	57,500
Annualized Cost ($/Yr)	17,800	17,800	17,800
Annualized Cost per Ton ($/T)[a]	0.108	0.054	0.036
		Scrubbing with White Liquor - Continuous Digesters	
Capital Cost ($)	47,500	47,500	47,500
Annualized Cost ($/Yr)	15,000	15,000	15,000
Annualized Cost per Ton ($/T)[a]	0.092	0.046	0.031
		Incineration in the Lime Kiln[b] - Batch Digesters	
Capital Cost ($)	129,000	176,000	243,000
Annualized Cost ($/Yr)	28,000	40,300	56,100
Annualized Cost per Ton ($/T)[a]	0.170	0.123	0.114
		Incineration in the Lime Kiln[b] - Continuous Digesters	
Capital Cost ($)	60,000	86,000	114,000
Annualized Cost ($/Yr)	15,000	22,000	30,000
Annualized Cost per Ton ($/T)[a]	0.091	0.067	0.061

[a] Based on 7884 hours of operation per year.

[b] It is assumed that a typical state regulation requires incineration; therefore, no incremental control costs exists for this affected facility.

as an alternative incineration point, particularly where explosion hazards are a concern, such as the case where an electrostatic precipitator may be used. See Section 8.2.1.2A(d) on the lime kiln.

The system for batch digesters requires a vapor sphere to act as a gas accumulator during the digester blows. The vapor sphere smoothes out the surges and allows a constant gas flow to be delivered to the lime kiln. Sources of cost data for this system include a design engineering company, operating companies, and the Sirrine report.[14] The costs for this alternative for batch and continuous digesters are shown in Table 8-13. As noted in the table, no incremental costs over state standards are assumed to occur for this affected facility.

b) Brown Stock Washers - The gas stream from the brown stock washers is a relatively large stream with a low concentration of TRS. The only control alternative judged feasible for this affected facility is incineration in the recovery furnace or another boiler within the mill. Since actual experience with this control alternative is limited, the degree of confidence in the control costs is not as good as the other cases.

The cost estimate includes the washer hoods, ducts, damper controls and an allowance for corrosion resistant features in the recovery furnace combustion air fan. The EPA cost estimate is based on the experience at the American Can Company mill at Halsey, Oregon.[15] Estimates from the National Council of the Paper Industry for Air and Stream Improvement, Inc. agree closely with the cost estimates presented in Table 8-14.[16] In building a

Table 8-14. CONTROL COSTS FOR THE BROWN STOCK WASHERS[a,b]

Mill Size, TPD	500	1000	1500
Capital Cost ($)	217,000	352,000	470,000
Annualized Cost ($/Yr)	43,000	70,000	94,000
Annualized Cost per Ton ($/Ton)[c]	0.261	0.213	0.190

[a] Based on incineration in the recovery furnace.

[b] Typical state regulations do not require any controls; therefore, the presented costs are also incremental control costs over State requirements.

[c] Based on 7884 hours of operation per year.

Table 8-15. BLACK LIQUOR OXIDATION COSTS

Mill Size, TPD	500	1000	1500
2-Stage Air Oxidation			
Capital Costs ($)	395,000	575,000	770,000
Annualized Costs ($/Yr)	141,000	210,000	290,000
Annualized Costs per Ton ($/T)[a]	0.858	0.639	0.588
1-Stage Air Oxidation[b]			
Capital Costs ($)	286,000	416,000	557,000
Annualized Costs ($/Yr)[c]	91,000	144,800	200,000
Annualized Costs per Ton ($/T)	0.554	0.441	0.406
2-Stage Oxygen Oxidation			
Capital Costs ($)	195,000	285,000	380,000
Annualized Costs ($/Yr)	193,000	350,000	511,000
Annualized Cost per Ton ($/T)	1.175	1.065	1.037

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[a] Based on 7884 hours of operation per year.

[b] Requirements for meeting state regulations (direct contact furnaces).

[c] Oxygen costs, $20 per ton oxygen, based on a 500 TPD oxygen plant.

is single stage weak liquor oxidation which has lower costs and can be used to satisfy state regulations for recovery furnace emissions. The costs in Table 8-15 compare closely with cost data gathered from operating companies and from the Sirrine report.[18]

An analysis was performed to estimate the costs for a black liquor oxidation system using pure oxygen. Since this method is only practiced in a couple of mills where low cost oxygen is available, it is not possible to make a precise cost estimate. The delivered cost of the oxygen is the variable that has the most significant effect on the cost of this alternative. For this analysis an oxygen cost of $20.00 per ton was assumed. This is the updated cost for a 500 ton per day oxygen plant based on an earlier report.[19] Obviously, only in special cases could a kraft pulp mill get oxygen at a delivered cost at $20.00 per ton or less. Examples of these special cases would be if the mill had its own oxygen plant to supply its oxygen bleaching plant or if the mill was located near a source of oxygen. Since no specific data is available on the capital cost for oxygen black liquor oxidation, the capital cost was estimated to be 50 percent of the capital cost for the air oxidation case. The costs for oxygen black liquor oxidation are shown in Table 8-15.

Table 8-16 shows the incremental costs for two-stage air oxidation systems versus the single stage air oxidation system suitable for compliance in most states.

d) Indirect Contact Recovery Furnaces - The control technique for reducing TRS emissions is the basic design of the indirect contact furnace system. The major recovery furnace manufacturers

Table 8-16. INCREMENTAL CONTROL COSTS FOR BLACK LIQUOR OXIDATION OVER STATE REQUIREMENTS (Air Oxidation Systems[a] for Direct Contact Furnaces)

Mill Size, TPD	500	1000	1500
Capital Costs ($)	109,000	159,000	213,000
Annualized Costs ($/Yr)	50,000	65,200	90,000
Annualized Costs per Ton ($/T)[b]	0.304	0.198	0.182

[a] 2-stage versus 1-stage systems.

[b] Based on 7884 hours of operation per year.

have several different furnace designs which can be classified as indirect contact furnaces. In general this means that the furnace system does not have a direct contact evaporator. Several methods are used to accomplish the function previously performed by the direct contact evaporator such as increasing the economizer section to recover more heat from the flue gas, adding a steam heated concentrator to evaporate water from the black liquor, or using combustion air heated by the furnace flue gas to evaporate water from the black liquor in an air contact evaporator.

The following procedure was used to estimate the incremental cost for indirect contact recovery furnaces over the requirements of typical state standards. The incremental costs were determined by taking the average cost difference, reported by the two major furnace manufacturers, between the indirect contact furnace and a direct contact furnace which has a direct contact evaporator and single-stage air oxidation of black liquor feed, and adding the cost of the concentrator reported by an engineering design company.[20]

The annualized cost is made up of maintenance, capital recovery, administrative overhead, property tax and insurance, and a charge for the incremental heat loss of the indirect contact furnace compared to the direct contact furnace. The heat loss is calculated assuming that the flue gas is 120°F hotter than the direct contact furnace flue gas. The cost of the heat loss is based on the following factors: the heat is made up by burning fuel valued at $1.50 per million Btu to produce steam in a boiler of 90 percent thermal efficiency. The annualized cost assumes a 90 percent operating factor or 7884 hours per year. The incremental capital and annualized costs are shown in Table 8-17. These costs are also the incremental control costs over the typical state requirements which could be met with a direct contact furnace plus a single stage of black liquor oxidation.

e) Black Liquor Oxidation System - The exhaust gases from air oxidation systems contains some TRS compounds. If these off-gases are to be controlled, the required control method is incineration. Two ways of designing incineration systems were considered. The first alternative involves incineration of the off-gases in the recovery furnace. Since the off-gas stream has a high moisture content, a condenser was considered a necessary part of the system. The second alternative investigated was incineration in a separate incinerator with heat recovery. An economic comparison of these two alternatives showed that incineration in the recovery furnace had a somewhat higher capital cost due to the condenser, but the annualized cost was considerably lower than for the separate incinerator. Given the rising cost and restricted availability of natural gas, the separate incinerator alternative is not considered to be a preferred alternative for this affected facility.

Since there are no existing installations of this type, no actual costs are available for this alternative. The costs in Table 8-18 represent EPA's best estimate of the cost of incineration

Table 8-17. INCREMENTAL COSTS FOR INDIRECT CONTACT RECOVERY FURNACE OVER TYPICAL STATE CONTROL REQUIREMENTS

Mill Size, TPD	500	1000	1500
Capital Cost ($)[a]	299,000	469,000	593,000
Annualized Costs ($/Yr)[b]	349,000	673,000	1,000,000
Annualized Costs per Ton ($/Ton)[c]	2.12	2.05	2.03

[a] Capital based on difference between indirect furnace plus concentrator and direct contact furnace, which includes direct contact evaporator and a single stage of black liquor oxidation.

[b] Includes capital related charges and heat loss.

[c] Based on 7884 hours of operation per year.

Table 8-18. CONTROL COSTS FOR INCINERATION OF BLACK LIQUOR OXIDATION SYSTEM OFF-GASES IN RECOVERY FURNACE

Mill Size, TPD	500	1000	1500
Capital Cost ($)[a]	200,000	305,000	400,000
Annualized Cost ($/Yr)	54,000	89,000	123,000
Annualized Cost per Ton[b] ($/T)	0.329	0.271	0.250

[a] Based on condensation and incineration in the recovery furnace.

[b] Based on 7884 hours of operation per year.

in the recovery furnace. Since most states do not require incineration of oxidation vents, these costs are also incremental control costs. The system includes the duct, condenser, piping, and controls required to transport the off-gases to the combustion air system of the recovery furnace. This system is similar to the one described for the brown stock washers except for the addition of a condenser.

f) Smelt Dissolving Tank - The control technique for reducing TRS emissions from the smelt dissolving tank is to use fresh water (or water which is essentially free of dissolved TRS compounds) in the smelt dissolving tank scrubber. This feature can be designed into a new mill at essentially no cost. Therefore, no control costs are presented for control of TRS emissions from this affected facility.

g) Lime Kiln - Two general approaches exist for reducing TRS emissions from lime kilns. The first is to maintain proper process conditions on parameters such as the cold end temperature, oxygen content in the kiln, the sulfide content in the lime mud, and the pH and the sulfide content of the scrubbing water. To accomplish some of these changes, more attention must be paid to operating the process, but it is difficult to identify specific cost penalties. The only factor which can be well defined enough to make a cost estimate is the increase in cold-end temperature. This cost is estimated based on raising the cold-end temperature 100° from 350° to 450°F and assuming $1.50 per million Btu and 7884 hours of operation per year. The control costs for each model mill are shown in Table 8-19.

The second approach to TRS removal is to add caustic to the liquor in the lime kiln scrubber. Caustic scrubbing will absorb some of the TRS emissions. For most mills caustic is part of the ordinary makeup caustic to the mill. In those cases, there is essentially no cost associated with this alternative. If the caustic is not ordinary makeup, then there is an additional cost for caustic addition. By filtering out the solids and recycling the caustic scrubbing liquid, consumption of caustic can be kept to a minimum. The cost for this caustic addition is calculated on the basis of 0.633 pound of caustic (NaOH) per ton of pulp at a price of $57 per ton of NaOH. The cost for the addition of caustic is shown in Table 8-19 where a scrubber is installed primarily for particulate controls.

In situations where electrostatic precipitators may be used for removal of particulates, the addition of caustic would require the installation of a scrubber to achieve TRS absorption. This unit would necessarily follow the precipitator in series. The rationale for the cost estimates of alternative 5 associated with TRS control includes the capital and annualized costs of a low energy scrubber in addition to the caustic consumption. The costs for the low energy scrubber are based on the estimates for the 15-inch scrubber from Table 8-11.

Table 8-20 shows the incremental control costs for alternative controls 2 through 5 over state standards requirements. Alternative 5 consists of combining process controls, a scrubber, and caustic

Table 8-19. CONTROL COSTS FOR LIME KILNS

Mill Size, TPD	500	1000	1500
Addition of 15" Scrubber with Caustic			
Capital Cost ($)	99,000	140,000	178,000
Annualized Cost ($/Yr)	54,300	99,300	143,700
Annualized Cost per Ton ($/T)[a]	0.331	0.302	0.292
Addition of Caustic Only			
Capital Cost ($)	0	0	0
Annualized Cost ($/Yr)[b]	3,000	6,000	9,000
Annualized Cost per Ton ($/T)[a]	0.0183	0.0183	0.0183
Process Control			
Capital Cost ($)	0	0	0
Annualized Cost ($/Yr)[c]	30,000	66,000	103,000
Annualized Cost per Ton ($/T)[a]	0.183	0.200	0.209

[a] Based on 7884 hours of operation per year.

[b] This cost applied only to mills where caustic is not part of the ordinary makeup.

[c] Based on fuel required to increase cold end temperature 100°F.

Table 8-20. INCREMENTAL CONTROL COSTS FOR ALTERNATIVE CONTROL SYSTEMS 2 THROUGH 5 ABOVE STATE REQUIREMENTS (LIME KILNS)

Mill Size, TPD	500	1000	1500
Alternative 5			
Capital Cost ($)	99,000	140,000	178,000
Annualized Cost ($/Yr)	84,300	165,000	246,700
Annualized Cost per Ton ($/T)	0.513	0.503	0.501
Alternatives 3, 4			
Capital Cost ($)	0	0	0
Annualized Cost ($/Yr)	30,000	66,000	103,000
Annualized Cost per Ton ($/T)	0.183	0.200	0.209
Alternative 2			
Capital Cost ($)	0	0	0
Annualized Cost ($/Yr)	33,000	72,000	112,000
Annualized Cost per Ton ($/T)	0.201	0.218	0.227

addition. Alternatives 3 and 4 include only process controls as defined above; and alternative 2, process controls and caustic addition. The costs are derived from the estimates presented in Table 8-19.

h) Condensate Stripper - In mills that have condensate strippers, the TRS compounds vented from the stripper can be controlled by incineration. The EPA cost estimate shown in Table 8-21 is based on a system including a fan, duct, seal pot, and flame arrester. The duct begins at the overhead condenser on the stripper and ends at the point where it connects with the non-condensible gas header which leads to the lime kiln.

In the judgement of EPA, the states normally would require incineration of condensate stripper vents. Hence, there are no incremental costs associated with this technique.

8.2.1.3 Discussion of Incremental Costs for Alternative Control Systems

The purpose of this section is to summarize the incremental control costs for each affected facility and to present total system costs which reflect alternative control considerations for the lime kiln facility. The total system costs (i.e., the aggregated incremental control costs on a total mill basis) serve as the input for the economic analysis in Section 8.4.

An in-depth description of the alternative control systems (Alternatives 1 through 5) is found in Section 4.3. A brief description in tabulated form of these alternative systems is presented in Table 8-22. Alternative 1 represents the composite of state regulations interpreted by EPA to be most typical for individual affected facilities. These

Table 8-21. CONTROL COSTS FOR THE CONDENSATE STRIPPER

Mill Size, TPD	500	1000	1500
Capital Cost ($)	15,000	21,000	26,000
Annualized Cost ($/Yr.)	5,800	7,200	8,200
Annualized Cost per Ton ($/Ton)[a]	0.035	0.022	0.017

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[a] Based on 7884 hours of operation per year.

Table 8-22. COMPARISON OF ALTERNATIVE CONTROL SYSTEMS

AFFECTED FACILITY	ALTERNATIVE CONTROLS				
	1[a]	2	3	4	5
Particulates					
Recovery Furnace (Direct Contact Only)	Medium Efficiency Precipitator (99.0%)	High Efficiency Precipitator (99.5%)	Same as 2	Same as 2	Same as 2
Smelt Dissolving Tank	Demister	Scrubber	Scrubber	Scrubber	Scrubber
Lime Kiln	15-inch Scrubber	30-inch Scrubber	Same as 2	Electrostatic Precipitator	Electrostatic Precipitator
TRS Emissions					
Digester/Multiple-Effect Evaporator	Incineration	Incineration	Incineration	Incineration	Incineration
Brown Stock Washers	No Control	Incineration	Incineration	Incineration	Incineration
Recovery Furnace (Direct Contact Only)	Single Stage Oxidation	Two Stage Oxidation	Same as 2	Same as 2	Same as 2
Black Liquor Oxidation Vents	No Control	Incineration	Incineration	Incineration	Incineration
Lime Kiln	Some Process Control	Improved Process Control plus Caustic	Improved Process Control	Same as 3	Improved Process Control plus 15" Scrubber with Caustic
Condensate Stripper	Incineration	Incineration	Incineration	Incineration	Incineration

[a] Control methods applicable for compliance with typical state regulations representative for specific affected facility.

regulations are not necessarily the most stringent ones that can be found. Rather, they are most representative of those states with pulp mill regulations, on an individual affected facility basis. Alternatives 2 through 5 are representative of more stringent levels of control.

The summary of incremental control costs derived earlier for the individual affected facilities is presented in Table 8-23. From these costs, total incremental costs for the alternative control systems can be derived. These are shown for the direct contact furnace only in Table 8-24.

Reviewing Table 8-23, the control costs on an unit basis tend to be lower with increasing mill size. However, the trend is not consistent and the economies of scale are not significant. For example, control alternative 2 costs range from $1.57 per ton for a 500 TPD mill to $1.47 per ton for a 1500 TPD mill; but the intermediate size, the 1000 TPD mill, has the lowest costs at $1.42 per ton. This pattern holds for alternative 3. For control alternatives 4 and 5, the costs per ton for the 1000 and 1500 TPD mills are practically the same at each level -- $1.99 per ton for alternative 4 and $2.29 per ton for alternative 5.

8.2.1.4 Cost-Effectiveness of TRS and Particulate Emission Control Alternatives, Lime Kiln Facility

With respect to lime kiln emissions, there are four levels that were considered for investigation. These levels which reflect the various combinations of controlling particulates and TRS emissions in-

Table 8-23. SUMMARY OF INCREMENTAL COSTS ABOVE STATE REGULATORY REQUIREMENTS PER AFFECTED FACILITY FOR DESIGNATED ALTERNATIVE CONTROLS

Mill Size, TPD	500			1000			1500		
Affected Facility	Capital Costs ($)	Annualized Costs ($/yr)	Unit Annualized Costs ($/T)	Capital Costs ($)	Annualized Costs ($/yr)	Unit Annualized Costs ($/T)	Capital Costs ($)	Annualized Costs ($/yr)	Unit Annualized Costs ($/T)
Particulates									
1. Recovery Furnace									
(a) Direct Contact	190,000	46,000	0.280	460,000	110,000	0.335	930,000	217,000	0.440
(b) Indirect Contact	310,000	67,000	0.408	620,000	132,000	0.402	825,000	154,000	0.304
2. Smelt Dissolving Tank	63,750	12,800	0.078	109,300	21,700	0.066	140,000	25,870	0.053
3. Lime Kiln									
(a) Alternatives 2,3	20,000	19,600	0.120	25,000	40,100	0.122	36,000	63,300	0.128
(b) Alternatives 4,5	207,000	131,000	0.800	302,000	232,200	0.707	367,000	329,600	0.670
TRS									
1. Recovery Furnace									
(a) Direct Contact	109,000	50,000	0.304	159,000	65,200	0.198	213,000	90,000	0.182
(b) Indirect Contact	299,000	349,000	2.12	469,000	673,000	2.05	593,000	1,000,000	2.03
2. Digester (Batch) and Multiple-Effect Evaporators	0	0	0	0	0	0	0	0	0
3. Brown Stock Washers	217,000	43,000	0.261	352,000	70,000	0.213	470,000	94,000	0,190
4. Black Liquor Oxidation System Vents (Direct Contact Furnace Only)	200,000	54,000	0.329	305,000	89,000	0.271	400,000	123,000	0,250
5. Lime Kiln									
(a) Alternative 2	0	33,000	0.201	0	72,000	0.218	0	112,000	0,227
(b) Alternative 3,4	0	30,000	0.183	0	66,000	0.200	0	103,000	0.209
(c) Alternative 5	99,000	84,300	0.513	140,000	165,300	0.503	178,000	246,700	0.501
6. Condensate Stripper	0	0	0	0	0	0	0	0	0

Table 8-24. SUMMARY OF AGGREGATE INCREMENTAL COSTS FOR ALTERNATIVE CONTROL SYSTEMS FOR DIRECT CONTACT RECOVERY FURNACE DESIGNS

MILL SIZE/COST CATEGORY	CONTROL ALTERNATIVES				
	1	2	3	4	5
500 TPD					
Capital Cost ($)	-	800,000	800,000	987,000	1,086,000
Annualized Cost ($/Yr)	-	258,400	255,400	367,000	421,300
Annualized Cost per Ton ($/T)	-	1.57	1.55	2.23	2.56
1000 TPD					
Capital Cost ($)	-	1,410,000	1,410,000	1,687,000	1,827,000
Annualized Cost ($/Yr)	-	468,000	462,000	654,000	753,400
Annualized Cost per Ton ($/T)	-	1.42	1.41	1.99	2.29
1500 TPD					
Capital Cost ($)	-	2,189,000	2,189,000	2,520,000	2,698,000
Annualized Cost ($/Yr)	-	725,200	716,200	982,600	1,126,300
Annualized Cost (Per Ton ($/T)	-	1.47	1.45	1.99	2.29

Note: Alternative 1 is the baseline representative of state requirements.

volve certain trade-off considerations that should be included in recommending the lime kiln standards.

The four levels have been described in detail earlier in Section 4.3. Basically alternative 2 differs from alternative 3 only by the addition of caustic (to a 30-inch pressure drop scrubber). Alternative 4 requires replacement of the 30-inch scrubber with an electrostatic precipitator to improve particulate emission control. In addition, a fuel penalty is incurred for use of the precipitator because the lime kiln can no longer be safely used as an incineration point for TRS emissions from other affected facilities. Alternative 5 represents an addition of a 15-inch pressure scrubber with caustic scrubbing liquid, to the alternative 4 controls, to achieve TRS absorption.

The calculations for cost effectiveness of selective particulate and TRS removals for ascending levels of control are presented in Table 8-25 for a direct contact recovery furnace design in a 1000 TPD pulp mill. The cost-effectiveness technique employed here attempts to measure the impact that a change in control technology has upon a reduction of a single pollutant category. Hence, the marginal cost concept is used to measure the sensitivity of such a change.

The marginal cost per lb. of pollutant reduction is calculated for the caustic addition alone ($0.73 per lb. of TRS reduction), for the electrostatic precipitator and separate incineration ($1.77 per lb. of particulate reduction), and the addition of a scrubber with caustic scrubbing liquid ($12.09 per lb. of TRS reduction).

Average costs per lb. of pollutant reduction are also shown in Table 8-25 for each level. The average costs shown for Alternative 2 are

Table 8-25. COST EFFECTIVENESS FOR 1000 TPD MILL (DIRECT CONTACT RECOVERY FURNACE)

PARAMETERS	ALTERNATIVE CONTROLS				
	1[a]	2	3	4	5
Incremental TRS reduction (lb/yr)	--	361,352	353,139	353,139	361,352
Incremental TRS control costs ($/yr)	--	296,200	290,200	290,200	389,500
Avg. cost per unit of TRS reduction ($/lb)	--	0.820	0.822	0.822	1.078
Δ Cost per Δ lb TRS reduction ($/lb)	--	0.731	--	--	12.09
* * *					
Incremental Particulate reduction (lb/yr)	--	886,950	886,950	995,355	995,355
Incremental Particulate control cost ($/yr)	--	171,800	171,800	363,900	363,900
Avg. cost per unit of particulate reduction ($/lb)	--	0.194	0.194	0.366	0.366
Δ cost per Δ lb particulate reduction ($/lb)	--	--	--	1.77	--

[a] Alternative 1 is the baseline of control, which represents compliance with states' regulations.

in reality marginal costs incremental above the state level (alternative 1). Alternative 2 average costs are calculated as if the alternative 1 costs were zero. To compute these costs in any other manner would entail the problem of defining the economic recovery for particulate emissions, which was discussed earlier in this chapter.

8.2.2 Modified/Reconstructed Sources

8.2.2.1 Introduction

The purpose of this section is to present control costs for modified and reconstructed sources that will evolve from the designation of certain affected facilities. Frequently, a pulp mill may expand production piecemeal, or improve production efficiency, by doing such things as reconstructing an existing digester, adding an additional stage of pulp washing, or converting to a more reliable fuel (such as converting from gas to coal in the lime kiln). Furthermore, a mill may make some major changes in its set-up in response to some non-production related consideration. An example of the latter would be the conversion of a direct contact furnace to an indirect contact furnace design to achieve reduction of TRS emissions for compliance with a state regulation. The examples presented here are precisely those that will be discussed with presentation of cost estimate.

Capital costs are based on 1975 dollars (Fourth Quarter of 1975). Capital charges are based on 15 years for amortization and 100 percent leading at 10 percent interest. Administrative costs, taxes, and insurance are estimated at 4 percent of capital investment. Factor prices for electricity and fuel are assumed to be the same as those in Section 8.2.1. Maintenance costs were calculated as 2 percent of original capital investments.

8.2.2.2 The Digester System

Reconstruction of an existing digester, in which an expenditure of more than 50 percent of the cost of a new unit is made, can be anticipated to occur at some mills. This action would require the control of the affected facility to meet the proposed standard. Control costs for two situations are presented:

1) case where only piping constitutes the major expense
2) case where the existing blow heat recovery system may have to be replaced (major costs for structural supports, blow heat tanks, heat exchangers). Included in both situations are costs for 2000 feet of piping (from the source to the lime kiln), spark arrestors, flame-out controls, and gas accumulator.

The costs represent estimates based on information received via contacts with several companies[21] for retrofitting controls in response to state implementation requirements. The costs estimates are presented in Table 8-26 for a 250, 500, and a 1000 ton per day mill.

8.2.2.3 Brown Stock Washer System

In some situations, a mill may expand sufficient pulping capacity to warrant a need for adding an additional washer stage to an existing washer system. Washer emissions may increase, thus subjecting the facility to the modification provisions of Section 111. In this particular case, the mill may have tightened down on all the major sources (recovery furnace, digesters), having only the washer system as the lone source for controls. Retrofit control costs are presented for such a situation.

Table 8-26. CONTROL COST REQUIREMENTS FOR DIGESTER RECONSTRUCTION

Case 1. Piping Only.

Mill Size, TPD	250	500	1000
Capital Cost ($)	$200,000	$350,000	$500,000
Annualized Costs ($/Yr)	51,000	90,000	136,000
Annualized Cost per Ton[a] ($/T)	0.621	0.548	0.414

Case 2. Piping and Blow-Heat Recovery.

Mill Size, TPD	250	500	1000
Capital Cost ($)	$500,000	$2,000,000	$4,000,000
Annualized Costs ($/Yr)	116,000	453,000	906,000
Annualized Cost per Ton ($/T)	1.41	2.76	2.76

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[a] Based on 7884 hours of operation per year.

The major factors involved in the magnitude of costs for retrofitting controls on brown stock washers are the accessibility of the recovery furnace for incineration of TRS and the condition of the ventilation system on the existing washers. Costs are presented for two cases: (1) major retrofit of ventilating system plus incineration in existing recovery furnace and (2) major retrofit of ventilating system plus destruction of captured TRS in a separate incinerator. Costs for retrofit of ventilation systems have been developed on the basis of contacts with several paper companies[22] and the National Council for Air and Stream Improvement.[23] The cost for a separate incinerator was based on transfer of technology from an incinerator application on an asphalt saturator.[24]

The cost estimates for these two situations are presented in Table 8-27 for 250, 500, and 1000 ton per day mills. The design gas flow rate for the incinerator was based on 100 acfm per ton per day pulp. This compares to a reported range of 75 to 250 acfm per ton per day.[25] Fuel costs were based on a price of $1.50 per million BTU and a use of 1.75 million BTU per ton pulp.

8.2.2.4 Recovery Furnace Modification

The only modification of a recovery furnace of any significance occurs when a direct contact design is converted to an indirect contact design. Only one situation of this nature has occurred in the industry although further conversions are likely to take place. For such a modification, the increased emission of concern is particulates.

Table 8-27. CONTROL COST REQUIREMENTS FOR BROWN STOCK WASHER MODIFICATIONS

Case 1. Incineration in Recovery Furnace

Mill Size, TPD	250	500	1000
Capital Cost ($)	400,000	600,000	1,200,000
Annualized Cost ($/Yr)	76,000	114,000	228,000
Annualized Cost per Ton ($/T)	0.925	0.694	0.694

Case 2. Separate Incinerator

Mill Size, TPD	250	500	1000
Capital Cost ($)	650,000	1,000,000	2,000,000
Annualized Cost ($/Yr)	315,000	570,000	1,140,000
Annualized Costs per Ton ($/T)	3.84	3.47	3.47

The only cost impact resulting from the New Source Performance Standards (NSPS) would be those costs related to the particulate control system. Since most states have particulate standards already, only those cost differences between compliance with the Federal NSPS and the state regulation are of importance. This means that the typical state regulation would require a collection system capable of achieving approximately 99.6 percent collection efficiency. In order to meet the Federal NSPS, the mill owner would have to install a system capable of achieving 99.8 percent. Since most of the retrofit costs, such as taking out the direct contact evaporator, adding economizer, concentrator, fans, turbines, piping, electrical, instrumentation, and engineering, would occur in the absence of any regulation, the only cost directly affected by the NSPS are the incremental precipitator costs. Referring to Table 8-28, these costs are presented for the 500 TPD mill and 1000 TPD mill situations. The costs are the same as those shown for indirect contact furnace precipitators in Table 8-8. The 250 TPD mill situation would not likely occur because most mills of that size would have furnaces approximately twenty years old and would be uneconomical to convert.

Table 8-28. INCREMENTAL CONTROL COSTS FOR INDIRECT CONTACT RECOVERY FURNACES OVER SIP REQUIREMENTS

Mill Size, TPD	500	1000
Capital Costs ($)	310,000	620,000
Annualized Cost ($/Yr.)	67,000	134,000
Annualized Cost per Ton ($/T)	0.41	0.41

8.2.2.5 Lime Kiln-Fuel Conversion

The anticipated modification of this source would occur for a conversion of gas fuel to oil for firing the kiln. This conversion would result in an increase of particulate emissions, thus subject to the Federal New Source Performance Standards.

The maximum impact foreseen would occur in the total replacement of the existing scrubber system. The costs for this situation which reflect the installation of a higher energy scrubber system are presented in Table 8-29. The capital costs, reflecting retrofit penalties, are assumed to be 25 percent greater than similar costs for a grass-roots Venturi scrubber, with 30 inch pressure drop. (The latter costs were presented in Table 8-11). The costs for the 250 TPD were obtained by scaling the costs in Table 8-11 with the assumption of a 0.4 scalar exponent over the 250-1500 TPD size range. The incremental annual costs include only the capital charges, taxes, insurance, and administrative costs and incremental electrical energy consumption. Maintenance costs, labor costs, and by-product credits are assumed to remain the same as those on the pre-retrofit scrubber.

This control option would not require any additional TRS controls, TRS emissions remaining the same as prior to retrofit. Hence, no need exists for addition of caustic.

Table 8-29. COST REQUIREMENTS FOR MODIFICATIONS TO LIME KILN SCRUBBER

Mill Size, TPD	250	500	1000
Capital Cost ($)	113,000	150,000	200,000
Annualized Costs ($/yr.)	27,000	41,000	65,000
Annualized Cost per Ton ($/T)	0.33	0.25	0.20

8.3 OTHER COST CONSIDERATIONS

In addition to NSPS, the fundamental process economics of the kraft pulping industry will be impacted by other regulations. These include Federal water regulations as well as occupational safety and health regulations. However, the imposition of these other regulations will probably not affect the results of the analyses contained in section 8.4.

Arthur D. Little, Inc. has recently completed a comprehensive analysis of air, water, and noise regulation impacts on the entire pulp and paper industry.[26] The kraft pulping sector was judged to be one of the stronger industry segments. Furthermore, ADL projected no closures for the kraft pulping sector.

8.4 POTENTIAL ECONOMIC (INCLUDING SOCIAL AND INFLATIONARY) IMPACT

8.4.1 Grass Roots New Plants and Capacity Additions at Existing Plants

The projected impact of each considered alternative control system is small for grass roots new plants and capacity additions at existing plants. New source performance standards should not, by themselves, preclude construction of grass roots new plants and capacity additions at existing plants.

Small absolute and relative control cost estimates, inelastic price elasticity of demand estimates, and small simulated return on investment impacts support the aforementioned statements.

8.4.1.1 Control Costs

The absolute and relative magnitude of the estimated alternative control systems' costs for grass roots new plants are displayed on Table 8-30. Regardless of the alternative of mill size, the estimated absolute and relative incremental control costs are small. At most, the estimated amounts are \$2.56 annualized cost per ton, 0.7% of the average pulp sales price, and 1.5% of the baseline mill investment. Although control costs tend to be higher for smaller mills with indirect contact recovery furnaces (See Table 8-23), the alternatives considered are not expected to significantly affect new mill size or recovery furnace design decisions. The reason is that air pollution control is just one of several factors influencing mill size and recovery furnace design. Moreover, the incremental control costs are small to begin with.

Table 8-30. ABSOLUTE AND RELATIVE INCREMENTAL CONTROL COSTS FOR NEW PLANTS
(in 4th Quarter 1975 Dollars)
Direct Contact Recovery Furnace Design

	Alternatives				
Mill Size/Cost Category	1	2	3	4	5
500 tpd					
Annualized Cost	-	$258400-	$255400-	$367000-	$421300-
Annualized Cost/Ton	-	$1.57	$1.55	$2.23	$2.56
Annualized Cost as a % of the 4th Quarter 1975 Average Selling Price of $345.50	-	0.5%	0.4%	0.6%	0.7%
Investment Cost	-	$800000-	$800000-	$987000-	$1,086,000-
Investment Cost as a % of Base Mill Investment of $87.5 mm	-	0.9%	0.9%	1.1%	1.2%
1000 tpd					
Annualized Cost	-	$468000-	$462000-	$654000-	$753400-
Annualized Cost/Ton	-	$1.42	$1.41	$1.99	$2.29
Annualized Cost as a % of the 4th Quarter 1975 Average Selling Price	-	0.4%	0.4%	0.6%	0.7%
Investment Cost	-	$1,410,000-	$1,410,000-	$1,687,000-	$1,827,000-
Investment Cost as a % of Base Mill Investment of $137.5 mm	-	1.0%	1.0%	1.2%	1.3%
1800 tpd					
Annualized Cost	-	$725200-	$716200-	$982600-	$1,126,300-
Annualized Cost/Ton	-	$1.47	$1.45	$1.99	$2.29
Annualized Cost as a % of the 4th Quarter 1975 Average Selling Price	-	0.4%	0.4%	0.6%	0.7%
Investment Cost	-	$2,189,000-	$2,188,000-	$2,520,000-	$2,698,000-
Investment Cost as a % of Base Mill Investment of $175.0 mm	-	1.3%	1.3%	1.4%	1.5%

Key:	Recovery Furnace		Smelt Dissolving Tank		Lime Kiln		BLO Vents	Br. Stk. Wshrs.	Digesters, Multiple Effect Evaporators, Condensate Strippers
	Particulates	TRS	Particulates	TRS	Particulates	TRS	TRS	TRS	TRS
Alternative 1 - The Average SIP	0.09 G/dscf	17.5 ppm	0.085 G/dscf	65 ppm	0.12 G/dscf	40 ppm	~40 ppm	~150 ppm	~5 ppm
2	0.04 G/dscf	5 ppm	0.05 G/dscf	5 ppm	0.06 G/dscf	5 ppm	5 ppm	5 ppm	~5 ppm
3	0.04 G/dscf	5 ppm	0.05 G/dscf	5 ppm	0.06 G/dscf	10 ppm	5 ppm	5 ppm	~5 ppm
4	0.04 G/dscf	5 ppm	0.05 G/dscf	5 ppm	0.02 G/dscf	10 ppm	5 ppm	5 ppm	~5 ppm
5	0.04 G/dscf	5 ppm	0.05 G/dscf	5 ppm	0.02 G/dscf	5 ppm	5 ppm	5 ppm	~5 ppm

The relative control costs associated with capacity additions at existing plants should be even smaller; since, there is more production volume over which to spread the incremental costs.

8.4.1.2 Price Elasticity of Demand

However, impact upon the mill or firm may depend on other things besides the control cost magnitudes. It might depend on the ability to pass control costs onto others.

For example, if kraft pulp prices rose to cover incremental control costs and sales revenues increased, lessened mill impact could result. To have a revenue rise, the percentage change in quantity demanded of kraft pulp divided by the percentage change in kraft pulp prices must have a value between 0 and -1.0. This occurs when the product's direct price elasticity of demand is inelastic.

Because kraft pulp is an intermediate good, has few close substitutes, and is a small part of final product value, most analysts characterize kraft pulp demand as price inelastic. This characterization is supported by recent econometric studies which estimate a direct price elasticity of demand value of -0.5.

8.4.1.3 Return on Investment

Control cost magnitudes and demand elasticities are revealing indicators of impact. However, where feasible,return on investment assessments are useful additions. Because such assessments focus on the viability of a particular investment [i.e. whether or not to construct a new mill], they more clearly focus on the issue of affordability.

Requisites of a return on investment assessment are the incremental investment, variable, and capital related control costs; baseline mill investment; variable process costs; the necessary price change; and demand elasticities.

Four critical assumptions were used in conducting the return on investment assessment. First, the project hurdle rate is 10% after tax. Second, variable process costs are $150/ton of pulp. Third, the demand elasticity of -0.5 applies to the price increase of each mill. And, fourth, the precontrol working year is 328.5 days.

The results of the assessment are displayed on Table 8-31. The adverse before tax return on investment impacts range from 0.04% to 0.11% for all considered alternatives. These are very small simulated impacts, and, by themselves probably would not alter decisions regarding new mill construction.

8.4.2 Modifications at Existing Plants

Modifications stem from capital improvements which increase the emission rate from a designated facility. Consequently, a mill segment becomes an affected facility; and hence, subject to "New Source Performance Standards" (NSPS).

Since modifications stem from capital improvements, the owner believes the mill, in the absence of NSPS, is a viable long run project. In essence, the owner makes the conscious decision to modify with the expectation of improving his competitive posture.

Table 8-31. SIMULATED RETURN ON INVESTMENT IMPACT: GRASS ROOTS NEW PLANTS
Direct Contact Recovery Furnace Design

Mill Size, Base Mill Investment; Variable Control Cost/Ton; Price; Quantity, Revenue, Cost, & Return on Investment Impacts	Alternatives 1	2	3	4	5
500 tpd; $87.5 mm Base Investment					
Variable Control Cost/Ton[1]	-	$0.73	$0.71	$1.20	$1.43
Price Increase[2]	-	$1.89	$1.87	$2.64	$3.01
Quantity Demanded Decrease[3]	-	449	444	628	715
Annual Revenue Change[4]	-	+$154500-	+$152900-	+$215000-	+$245200-
Annual Fixed Cost Change[5]	-	+ 137200-	+ 137200-	+169300-	+ 186300-
Annual Variable Process Cost Change[6]	-	- 67400-	- 66600-	- 94200-	- 107300-
Annual Variable Control Cost Change[7]	-	+ 119600-	+ 116300-	+196300-	+ 233900-
Annual Income Change Before Tax[8]	-	- 34900-	- 34000-	- 56400-	- 67700-
Return on Investment Change Before Tax[9]	-	- 0.04%	- 0.04%	- 0.06%	- 0.08%
1000 tpd; $137.5 mm Base Investment					
Variable Control Cost/Ton	-	$0.68	$0.67	$1.11	$1.34
Price Increase	-	$1.71	$1.70	$2.34	$2.67
Quantity Demanded Decrease	-	813	813	1112	1269
Annual Revenue Change	-	+$279500-	+$276200-	+$381900-	+$435300-
Annual Fixed Cost Change	-	+ 241800-	+ 241800-	+ 289300-	+ 313300-
Annual Variable Process Cost Change	-	- 122000-	- 122000-	- 166800-	- 190400-
Annual Variable Control Cost Change	-	+ 222800-	+ 219600-	+ 363400-	+ 438500-
Annual Income Change Before Tax	-	- 63100-	- 63200	- 104000-	- 126100-
Return on Investment Change Before Tax	-	- 0.05%	- 0.05%	- 0.07%	- 0.09%
1500 tpd; $175.0 mm Base Investment					
Variable Control Cost/Ton	-	$0.71	$0.69	$1.11	$1.35
Price Increase	-	$1.77	$1.75	$2.33	$2.66
Quantity Demanded Decrease	-	1262	1248	1662	1897
Annual Revenue Change	-	+$433900-	+$428900-	+$570000-	+$650300-
Annual Fixed Cost Change	-	+ 375400-	+ 375400-	+ 432180-	+ 462710-
Annual Variable Process Cost Change	-	- 189300-	- 187200-	- 249300-	- 284550-
Annual Variable Control Cost Change	-	+ 349000-	+ 339100-	+ 545100-	+ 662700-
Annual Income Change Before Tax	-	- 101200-	- 98400-	- 158000-	- 190600-
Return on Investment Change Before Tax	-	- 0.06%	- 0.06%	- 0.09%	- 0.11%

Footnotes:

[1] Variable Control Cost/ton = (Annualized Control Cost - Annual Fixed Cost) ÷ (daily tonnage x 328.5 days)

[2] Price Increase/ton = Variable Control Cost/ton + [Investment Cost (.1989 + .04)] ÷ (daily tonnage x 328.5 days)

[3] Quantity Demanded Decrease = [0.5 x (Price Increase ÷ $345.50)] x (daily tonnage x 328.5 days)

[4] Annual Revenue Change = Price Increase x [(daily tonnage x 328.5) - Quantity Demanded Decrease]

[5] Annual Fixed Cost Change = Investment (depreciation and interest factor of .1315 + property tax, insurance, and overhead factor of .04)

[6] Annual Variable Process Cost Change = $150.00 x Quantity Demanded Decrease

[7] Annual Variable Control Cost Change = Variable Control Cost/ton x [(daily tonnage x 328.5) - Quantity Demanded Decrease]

[8] Annual Income Change Before Tax = Annual Revenue Changes - Annual Cost Changes

[9] Return on Investment Change Before Tax = Annual Income Change Before Tax ÷ (Base Mill Investment + Control Investment)

The fundamental question in the impact assessment is will the owner still wish to modify in the face of NSPS. For the 4 modification cases analyzed, the control costs are probably affordable; the owner would probably still modify. Small incremental control costs, inelastic demand estimates, and small simulated return on investment impacts support the aforementioned statement.

The probable modifications and their control costs are described in Section 8.2.2. Kraft pulp demand elasticity is described in Section 8.4.1.2. The modification return on investment assessment employs the same critical assumptions and requisite data as the new mill assessment. However, baseline mill investment for the modification assessment is assumed to be 50% of the new mill assessment.

The results of the modification assessments are displayed on Table 8-32. Adverse return on investment impacts range from a decline of 0.01% to 0.32%. Again, these are small numbers, and by themselves would probably not alter a mill's decision regarding modification.

8.4.3 Reconstructions at Existing Plants

Reconstructions may result when capital expenditures on a designated facility exceed 50% of the cost of a new facility. The absolute and relative magnitude of associated control costs would probably be less than the previously analyzed new plant and modified existing plant situations. For example, piecemeal reconstructions would have smaller associated gas volumes and hence, smaller control costs. In addition, production levels are presumed to be the same in the modified and reconstructed mill situations. Consequently, the impacts on reconstructions at existing mills would probably be less. Therefore, the concluded impact of all alternatives on reconstructions at existing mills is small.

Table 8-32. SIMULATED RETURN ON INVESTMENT IMPACT: MODIFICATIONS AND RECONSTRUCTIONS AT EXISTING PLANTS

Mill Size, Base Mill Investment, Variable Control Cost/Ton, Price, Quantity, Revenue, Cost, & Return on Investment Impacts	Digester Reconstruction[1] Case 1 Piping & Stand-by Incinerator Required	Digester Reconstruction[1] Case 2 Piping, Heat Exchanger, & Stand-by Incinerator Required	Brown Stock Washer Stage Addition[2] Case 1 Incinerate in Recovery Furnace or Power Boiler	Brown Stock Washer Stage Addition[2] Case 2 Separate Incinerator Required	Convert from Direct Contact to Indirect Contact Recovery Furnace[3] Another Precipitator Required	Convert Lime Kiln Fuel from Gas to Oil[4] A 30" Δ Scrubber Required
250 tpd; $21.9 mm Base Investment						
Variable Control Cost/Ton	$0.20	$0.37	$0.09	$2.48	Not Applicable	$0.09
Price Increase	$0.78	$1.82	$1.25	$4.37		$0.42
Quantity Demanded Decrease (Tons)	91	216	149	519		50
Annual Revenue Change	$+31900-	$+74400-	$+51000-	$+177300-	↓	$+17200-
Annual Fixed Cost Change	+ 34300-	+85800-	+68600-	+111480-		+19400-
Annual Variable Process Cost Change	- 14000-	-32400-	-22400-	- 77900-		- 7500-
Annual Variable Control Cost Change	+ 16400-	+30300-	+ 7400-	+202400-		+ 7400-
Annual Income Change Before Tax	- 4800	- 9300-	- 2600-	- 58700-		- 2100-
Return on Investment Change Before Tax	- 0.02%	- 0.04%	- 0.01%	- 0.26%		- 0.01%
500 tpd; $43.8 mm Base Investment						
Variable Control Cost/Ton	$0.18	$0.67	$0.06	$2.43	$0.09	$0.09
Price Increase	$0.69	$3.58	$0.93	$3.88	$0.54	$0.31
Quantity Demanded Decrease (Tons)	164	851	221	922	128	74
Annual Revenue Change	$+56600-	$+290900-	$+76200-	$+315200-	$+44400-	$+25300-
Annual Fixed Cost Change	+60000-	+343000-	+102900-	+171500-	+53200-	+25700-
Annual Variable Process Cost Change	-24600-	-127700-	-33200-	-138300-	-19200-	-11100-
Annual Variable Control Cost Change	+29500-	+109500-	+ 9800-	+396900-	+14800-	+14800-
Annual Income Change Before Tax	- 8300-	- 33900-	- 3300-	-114900-	- 4400-	- 4100-
Return on Investment Change Before Tax	- 0.02%	- 0.07%	- 0.26%	- 0.26%	- 0.01%	- 0.01%
1000 tpd; $68.8 mm Base Investment						
Variable Control Cost/Ton	$0.15	$0.67	$0.06	$2.43	$0.09	$0.10
Price Increase	$0.51	$3.58	$0.93	$3.88	$0.54	$0.25
Quantity Demanded Decrease (Tons)	242	1702	442	1845	257	119
Annual Revenue Change	$+83800-	$+581900-	$+152400-	$+630000-	$+88500-	$+41000-
Annual Fixed Cost Change	+85800-	+686000-	+205800-	+343000-	+106300-	+34300-
Annual Variable Process Cost Change	-36300-	-255300-	- 66300-	-276800-	-39600-	-17900-
Annual Variable Control Cost Change	+49200-	+219000-	+ 19700-	+793800-	+29500-	+32800-
Annual Income Change Before Tax	-14900-	- 67800-	- 6800-	-230000-	- 8700-	- 8200-
Return on Investment Change Before Tax	- 0.02%	- 0.09%	- 0.01%	- 0.32%	- 0.01%	- 0.01%

Footnotes:

[1] Replacement of components costing more than 50 percent of the cost of a new facility.

[2] If emissions increased and the bubble concept could't be applied, washer stage addition would represent a modification under alternative 1, 2, 3, 4, or 5.

[3] If emissions increased and the bubble concept couldn't be applied, furnace conversion would represent a modification under alternative 1, 2, 3, 4, or 5.

[4] If emissions increased and the bubble concept couldn't be applied, and the kiln was designed for oil, fuel conversion would represent a modification under alternative 1, 2, 3, 4, or 5.

Reconstructions at existing plants will probably not be precluded by an NSPS alone.

8.4.4 Summary

In essence, the projected impact of all considered alternatives is small. Again, small incremental control costs, inelastic price demand elasticity estimates, and small simulated return on investment impacts support the projected impact. New source performance standards by themselves should not preclude new mill construction or modification and reconstruction of designated facilities at existing mills. Consequently, adverse growth, output, and employment impacts are probably nil.

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9. RATIONALE FOR THE PROPOSED STANDARDS

9.1 SELECTION OF THE SOURCE FOR CONTROL

Kraft pulp mills contribute significantly to national emissions of total reduced sulfur (TRS) and particulate matter. There are currently 120 mills located in 28 states that produce over 90,000 tons of pulp per day. Nationwide emissions of TRS from kraft pulp mills exceeded 200,000 tons in 1973; emissions of particulate matter totaled 400,000 tons during the same year. The industry is experiencing a moderate growth rate of about 2.5 percent that is predicted to continue through the end of the decade. However, the rate is predicted to return to a higher growth rate by 1980. Standards based on best demonstrated technology would have a significant impact on emissions from newly constructed and modified facilities.

Total Reduced Sulfur (TRS)

The reduction in TRS emissions from all domestic affected facilities due to the increased control requirements of the proposed standards is estimated to exceed 14,350 tons per year in 1980. This number is based on anticipated growth rates in new and modified facilities. Compared to emission rates under present average state control standards, an increase in TRS emission control efficiency of about 96 percent can be anticipated.

TRS is an extremely odorous gas, often detectable at concentrations of a few parts per billion. Odors from poorly controlled kraft pulp mills may affect large areas and populations and may cross State and national boundaries. Interstate activities and international air pollution problems have been caused by these emissions. For example, the State of Vermont sued the State of New York and

International Paper Company over odorous emissions linked to a pulp mill at Ticonderoga, New York. The suit resulted in increase in TRS emissions control from the mill in an effort to reduce the intensity and range of effect of the odors. EPA was retained as a friend of the court and supplied technical information. Emissions from kraft pulp mills near several other State border areas have prompted similar involvement by EPA in the settlement of interstate odor problems.

TRS at kraft pulp mills consists of hydrogen sulfide, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide. Based on the results of several studies,[1,2] the odor thresholds of these gases are:

	Odor Threshold	
Compound	ppm	$\mu g/m^3$
Hydrogen Sulfide - H_2S	.0005-.022	<1-45
Methyl Mercaptans - CH_3SH	.0021	4.5
Dimethyl Sulfide - $(CH_3)_2S$	.0010	2.9
Dimethyl Disulfide - $(CH_3)_2S_2$	.0056	23.7

The perception of these odors varies from person to person, depending on many factors such as age, sex, location, general health, and smoking habits. In the vicinity of poorly controlled kraft pulp mills, average ambient ground level concentrations of TRS as high as 3000 $\mu g/m^3$ (one-hour average) have been measured. Under adverse dispersion conditions, concentrations as high as 1400 $\mu g/m^3$ (10-second average) and 185 $\mu g/m^3$ (1 hour average) are predicted from meteorological studies[6]. The calculated ambient ground level concentration of TRS due to emissions from well controlled facilities at a model 1000-ton-per-day mill is about 225 $\mu g/m^3$ (10 second average) 30 $\mu g/m^3$ (one-hour average). The meterological study is discussed in detail in Chapter 7.

These concentration levels are of short duration and are representative of the worst case that is predictable under the assumed emission conditions. Control of TRS emissions to the level required by the proposed standards will substantially reduce the intensity of the odorous emissions and the affected area where the ordors are preceptable.

The available information on the effects of TRS on the public health or welfare is oriented toward the effects of hydrogen sulfide (H_2S) and of odors. Since approximately 75 percent of TRS emitted from kraft pulp mills is H_2S, and odors are linked to the emission of all four of the constituent gases of TRS, the following discussion primarily addresses the effects due to the presence of H_2S and odors.

The effects of H_2S in the ranges predicted near kraft pulp mills are summarized in Table 9.1. At the lower concentrations only odor perception and slight eye irritation are noted. As the concentration ranges above 15,000 $\mu g/m^3$, other irritant effects may be experienced. Above 30,000 $\mu g/m^3$ the maximum occupational 8-hour exposure limit is exceeded. The Illinois Institute for Environmental Quality[7] noted that at levels between 10,000 and 70,000 $\mu g/m^3$ of H_2S, symptoms such as eye irritation, fatigue, loss of appetite, insomnia, nausea, and headaches will occur following long duration. At very high concentrations, over 1,000,000 $\mu g/m^3$, exposure to hydrogen sulfide can cause death quickly by paralysis of the respiratory center. The

TABLE 9.1

EFFECTS OF HYDROGEN SULFIDE[3]

H_2S Concentration $\mu g/m^3$ (ppm)	Recorded Effects
1-45 (7.2×10^{-4} - 3.2×10^{-2})	Odor threshold. No reported injury to health
10 (7.2×10^{-3})	Threshold of reflex effect on eye sensitivity to light
150 (0.10)	Smell slightly perceptible
500 (0.40)	Smell definitely perceptible
15,000 (11.0)	Minimum concentration causing eye irritation
30,000 (22.0)	Maximum allowable occupational exposure for 8 hours (ACGIH Tolerance Limit)
30,000-60,000 (22.0-43.0)	Strongly perceptible but not intolerable smell. Minimum concentration causing lung irritation
150,000 (110)	Olfactory fatigue in 2-15 minutes; irritation of eyes and respiratory tract after 1 hour; death in 8 to 48 hours

sensation of odor at these levels is often lost due to olfactory fatigue after short exposure periods, which increases the danger of exposure. Concentrations at these levels, however, are not expected to occur as a result of emissions from kraft pulp mills alone.

Studies indicate little evidence that hydrogen sulfide causes any significant injury to field crops at ambient concentrations below 30,000 $\mu g/m^3$. Effects have been noted, however, on painted surfaces and metals. H_2S may react with paint containing heavy metal salts to form a precipitate which can darken and discolor the surface. Experiments have shown that darkening is dependent on both the duration of exposure and the concentration at the surface. Darkening has occurred after exposure to H_2S concentrations as low as 75 $\mu g/m^3$ for two hours. Damage to house paint caused by H_2S emissions linked to a kraft pulp mill has been reported in studies on the communities of Lewiston, Idaho, and Clarkston, Washington. H_2S has been linked to the tarnishing of copper and silver surfaces exposed to concentrations above 4 $\mu g/m^3$ for 40 hours. It will also cause some alloys of gold to tarnish and has been shown to attack zinc at room temperature, forming a zinc sulfide film. However, at concentrations normally expected in the atmosphere at kraft pulp mills, H_2S is not corrosive to ferrous metals.

Hydrogen sulfide is characterized by a "rotten eggs" smell that is perceptable at the low levels previously cited. Several studies have linked the presence of odors of the type emitted from kraft pulp mills to trends in several effects on humans, such as poor appetite, impaired respiration, nausea, vomiting, insomnia, and mental perturbation. Odors have also been associated with aggravation of symptoms of chronic respiratory illness and may induce attacks of asthma or other allergic conditions. The presence of odors may also reduce the value of property within the affected area, depending upon the extent to which the odors are considered objectionable to the buyer and seller of the property.[2,4]

Particulate Matter

Emissions of particulate matter from facilities controlled to the average state standard level may exceed 5.5 lb/T ADP (1000-ton-per-day mill). Meteorological studies have shown that ambient concentrations due to emission rates of this magnitude may range as high as 180 $\mu g/m^3$ (24-hour average), exceeding the secondary National Ambient Air Quality Standard (NAAQS) set for particulate matter in any given region; the primary NAAQS of 260 $\mu g/m^3$ may also be exceeded.

The reductions in particulate matter emissions at all facilities at domestic kraft pulp mills due to the increased control requirement over existing state levels is estimated to exceed 7,300 tons per year in 1980. This represents an increase in particulate control efficiency of approximately 50 percent.

Health-related effects of particulate matter on humans have been documented at ambient concentrations in the ranges calculated for the kraft pulp mill emissions cited above. Effects of particulate matter on exposed materials have also been identified.[8] Under section 109 of the Clean Air Act, particulate matter has been designated as a criteria pollutant, and thus must be controlled to the degree necessary to attain the ambient standards.

EPA has determined that emissions of TRS and particulate matter from kraft pulp mills contribute to air pollution which causes or contributes to the endangerment of the public health or welfare. Interstate and international control problems have prompted the need for control of these sources. Significant reductions in the mass emissions from these sources are possible through application of best demonstrated technology, considering costs. With the control of the mass emissions, large reductions in the ambient concentrations can also be realized. A 1975 report by The Research Corporation of New England performed for EPA[5] lists kraft pulp mills high on the list of major sources requiring nationwide control of H_2S. The study concludes that control of kraft pulp mill emissions through NSPS will result in significant beneficial impacts on the quality of the air within the affected regions.

A survey of the social and economic impact of odors conducted for EPA in 1971-1973 by Copley International Corporation[4] found that the pulp and paper industry was ranked in the upper quarter of all odor sources in terms of both odor producing potential and objectionability of the odorous emissions. For all of these reasons, the source category of kraft pulp mills has been selected for emission control.

9.2 SELECTION OF POLLUTANTS AND AFFECTED FACILITIES

Emissions of TRS primarily occur at eight facilities in a kraft pulp mill: the digester system, the brown stock washers, the multiple-effect evaporators, the black liquor oxidation system, the recovery furnace, the smelt dissolving tank, the lime kiln, and the condensate stripping system. Significant sources of particulate emissions are the recovery furnace, the smelt dissolving tank, and the lime kiln. These eight facilities account for virtually all of the TRS and particulate emissions from an average mill. A breakdown of emissions from these facilities is discussed in chapter 2 and summaries of the levels obtained during the test program are presented in chapter 6 and Appendix A.

Kraft pulp mills have also been shown to be sources of emissions of SO_2, NO_x, and CO. These pollutants result from combustion in the recovery furnace and the lime kiln. The levels at which these pollutants are released are relatively low with respect to such large sources as power plants. Control of these pollutants from kraft pulp mills under new source performance standards is not presently being considered, however, since no economical control technology for kraft pulp mills has been adequately demonstrated.

An additional potential source of TRS at many kraft pulp mills is the treatment pond facilities. TRS emissions from these operations vary from mill to mill due to differences in wood type and content of the effluent stream. Two main causes of TRS emissions from treatment ponds that have been identified are the liberation of dissolved sulfides in the water and the generation of sulfides by biological action within the pond. Standards requiring aerobic operation of treatment ponds at kraft pulp mills have been proposed, and will prevent the anaerobic production of hydrogen sulfide. Stripping of the waste condensate stream will prevent the presence of the dissolved sulfides. Methods for measuring TRS emissions from kraft pulp mill treatment ponds are not presently available. EPA has decided not to propose standards to control this source at present but is considering further investigation of possible measurement and control technology as a basis for future Agency action.

Definition of Affected Facility

9.2.1 Digester System

The number of digesters used at a kraft pulp mill is highly variable. As few as one and as many as 34 individual digesters are being used at mills in the United States. In addition, mills may use either batch digesters or continuous digesters. The affected facility in this case could be defined as each individual digester unit, all the digester units at a mill, or all the batch digesters and all the continuous digesters at a mill.

The definition of the affected facility affects the way in which the emissions from existing digesters are covered by the modification provisions. If the affected facility is defined as the system of units, an addition of a new digester would be a potential modification. The new digester would contribute additional TRS emissions from the facility. These emissions would have to be controlled or traded off, under the "bubble concept," elsewhere in the same mill. If, however, each individual batch or continuous digester is defined as the affected facility, any additional digesters would be designated as new facilities, the emissions from which would be subject to the proposed standards.

To obtain maximum control of the emissions from new and reconstructed digesters, the affected facility is defined as "each batch or each continuous digester used for the cooking of wood in white liquor, and associated flash tank(s), blow tank(s), chip steamer(s), and condenser(s)."

9.2.2 Brown Stock Washer System

The brown stock washers at kraft pulp mills are usually of the vacuum filter design, employing either three or four stages of washing in each line. It is difficult to distinguish between emissions from the individual washers in each line. In addition, the knotters, vacuum pumps, and filtrate tanks are potential emissions points within a washer system. The affected facility is therefore defined to cover all of the emissions from each line of washers: "each system of washers, knotters, vacuum pumps, and filtrate tanks used to wash the pulp following the digestion process."

9.2.3 Multiple-Effect Evaporator System

The design of the evaporator system may vary from mill to mill depending on the number and configuration of the associated recovery furnaces. Multiple lines of evaporators may serve one furnace, or a single line of evaporators may feed to more than one furnace. It would be difficult to base the definition of the affected facility on the recovery furnace(s), because of the variety of designs encountered in the industry. Therefore, the entire evaporator system is defined as the affected facility, along with the "associated condenser(s) and hotwell(s) used to concentrate the black liquor."

9.2.4 Black Liquor Oxidation System

As with the multiple-effect evaporators, the design and layout of the black liquor oxidation system varies from mill to mill. Single, double, and triple stage oxidation systems are all presently used in the industry. Oxidation of weak black liquor and strong black liquor may also be found at one mill.

The affected facility could be defined either as each individual oxidation tank or as all of the black liquor oxidation processes at a mill. The main purpose of adding an additional stage of oxidation at a mill is to decrease TRS emissions from the recovery furnace. Defining each individual oxidation tower as the affected facility would require control of emissions from the additional new unit, even though the increase in emissions is small compared to the reduction in TRS emissions from the furnace. The second alternative, however, would allow the small incremental increase from the oxidation system to be traded off under the "bubble concept" with the reduction in furnace emissions. Therefore, the affected facility is defined as "all of the vessels used to oxidize, with air or oxygen, the black liquor, and associated storage tanks."

9.2.5 Recovery Furnace System

Each recovery furnace is defined as an affected facility. Generally, each furnace is a separate entity and does not interact with any other furnace at a mill. If a furnace is used for recovery of materials from both kraft and neutral sulfite semi-chemical pulping operations, it is covered by the proposed standards.

9.2.6 Smelt Dissolving Tank

The smelt dissolving tank associated with each recovery furnace is a separate unit with no interconnections with any other tank at a mill. Therefore, the affected facility is defined as each "vessel used for dissolving the smelt collected from the recovery furnace."

9.2.7 Lime Kiln

Each lime kiln operates separately from any other kiln at a mill, with no dependence or interaction between kilns. Therefore, the affected facility is defined as each "unit used to calcine lime mud...into quicklime."

9.2.8 Condensate Stripper System

Only three mills currently use a condensate stripper system, and each of these mills has only one unit in operation. Although it is conceivable that a mill could operate multiple units in parallel, it is expected that all new condensate strippers will be installed as separate systems. The definition of the affected facility is therefore each "column, and associated condensers, used to strip, with air or steam, TRS compounds from condensate streams from various processes within a kraft pulp mill."

9.3 SELECTION OF BEST SYSTEM OF EMISSION REDUCTION CONSIDERING COSTS

The purpose of the proposed standards is to require that best emission control technology, considering costs, for TRS compounds and particulate matter be installed and operated at new and modified kraft pulp mills. The individual emission sources to be controlled include all process gas streams at kraft pulp mills which are significant sources of TRS and particulate matter. The proposed standards are based on data on emission control systems and methods of process operation received through (1) on-site observations of plant processes and control equipment, (2) consultation with industry representatives and control equipment vendors, (3) emission tests conducted by EPA and operators of kraft pulp mills, and (4) meetings with the National Air Pollution Control Techniques Advisory Committee (NAPCTAC).

The selection of the best system of emission reduction considering costs is based on an evaluation of the incremental impacts (compared to average state standards) on air emissions, air pollution control costs, energy requirements, water pollution and solid waste pollution. The first step is to select the most effective emission reduction methods for each affected facility. Then the impacts of the individual methods are compared to determine the best emission reduction method. The best system to control TRS and particulate matter from an entire kraft mill is an assimilation of the best emission reduction method or methods for each facility, since the emissions from each facility at a kraft mill are independent of emissions from other facilities.

9.3.1 Recovery Furnace

The recovery furnace is the largest single source of particulate matter and TRS pollutants at a kraft mill. TRS emissions are generated primarily during contact of combustion gases with the black liquor in a direct-contact system, and to a lesser degree as a result of the combustion process in the furnace. Proper control of the black liquor firing rate, the oxygen concentration within the furnace, and the air-to-solids ratio during operation are necessary to reduce the TRS emissions from the furnace. Particulate matter is generated during the black liquor combustion and consists mainly of sodium salts.

TRS Emissions - In addition to the proper operation of the furnace, there are two methods that are in use to reduce TRS emissions from the recovery furnace: (1) the use of a black liquor oxidation system in combination with a direct-contact evaporator (conventional method), and (2) the elimination of the direct-contact evaporator in an indirect-contact furnace. One or the other of these two methods of TRS reduction is currently used at all domestic mills. Currently being demonstrated is a new control system which the vendor claims will reduce TRS emissions to the same level as that achieved by either black liquor oxidation or indirect-contact furnaces. This control system is a cross flow caustic scrubber using activated carbon as a catalyst. EPA has not had the opportunity to test or fully evaluate this control system, and it may represent another viable control option. There are no additional TRS reduction technologies that are expected to be demonstrated in the near future.

The typical state standard for recovery furnaces is about 17.5 ppm. This level is achievable by the use of either control system, indirect-contact evaporation or direct-contact evaporation with black liquor oxidation. However, EPA feels that the indirect-contact evaporation system is capable of achieving much lower levels and is more efficient than would be required to meet the average state standard. Therefore, the baseline system, upon which the impacts associated with the alternative control levels are compared, requires control of TRS emissions with a single stage of black liquor oxidation and application of process controls with a direct-contact evaporator system.

The two types of systems, indirect-contact evaporation and direct-contact evaporation with two or more stages of black liquor oxidation, are judged to be equally effective in controlling TRS emissions to meet the level of the proposed standard. Source tests by EPA have shown that indirect-contact systems can achieve a slightly lower level in some cases. However, when the fluctuations in emissions from the indirect-contact system is taken into account, both systems are considered equivalent for TRS control.

Neither method produces significant water or solid waste pollution. The indirect-contact furnace requires a larger capital expenditure than a conventional furnace because a larger economizer section is required on the furnace and an additional steam evaporator is also required. Consequently, the indirect-contact furnace has a larger annual expense because of the annual charges associated with the increased capital and a fuel charge due to heat loss. This is discussed in detail in chapter 8. The incremental capital costs and operating costs over the average State standards are considered to be reasonable for both methods. The energy requirements for a mill that uses an indirect-contact furnace, as a percentage of the total plant fossil fuel and electrical requirements, are as much as 10 percent higher than the mill using a direct-contact furnace. This is due to an estimated effective flue gas heat loss of 120°F. This heat loss arises because the optimum economizer for an indirect-contact furnace and the process stream requirements result in the combustion gases leaving at a higher temperature, and some additional steam is also required in the additional evaporator unit.

Particulate Emissions - The two demonstrated methods for controlling particulate matter from the recovery furnace are scrubbing and electrostatic precipitation (ESP). Fabric filtration has been considered by some operators, but it has not been demonstrated and is not considered to be currently available. For a scrubber to achieve the particulate emission control levels attainable with an ESP (0.02-0.05 gr/dscf), a very high pressure drop would be required. The very few scrubbers that are presently used for control of particulate emissions from recovery furnaces have relatively low collection efficiencies compared to an ESP.

The industry[10] has commented that there is a gradual deterioration in performance over the life of an ESP in the kraft industry, even if the precipitator is well maintained. The industry also commented that the performance of an ESP should be allowed to deteriorate until a sufficient amount of maintenance is necessary to justify shutting down the unit and performing the maintenance.

EPA investigated these comments by contacting plant operators and discussing these comments with equipment vendors.[11,12] EPA's conclusions, discussed in detail in chapter 4, are that a precipitator will not significantly deteriorate with age provided the wires, collection plates, and rapping system are well maintained. The vendors contacted by EPA agreed that the design of precipitators to be used on kraft recovery furnaces should be more rugged than for most other applications because the particulate matter from kraft furnaces is sticky and requires intensive rapping to separate it from the collection plates, thereby requiring a more sturdily built precipitator. Some precipitators that **are** ruggedly designed have recently been put into use in the domestic kraft pulping industry. The wires on this type of precipitator are fastened at five-foot intervals, and very few wires have broken in operation.

Currently precipitators for the kraft industry are designed to achieve an emission level of 0.05 g/dscm. EPA has tested three units that achieve particulate concentrations below this design level. EPA agrees with the industry that the performance of a precipitator should be allowed to deteriorate somewhat (until a sufficient amount of maintenance is necessary to justify shutting down the unit and performing the maintenance), but feels that this has been adequately considered in setting the proposed standard of 0.10 g/dscm.

There are no water or solid waste impacts associated with ESP's used on recovery furnaces because the collected particulate matter, which is salt cake, is recycled directly back to the process. State standards require a collection efficiency of approximately 99 percent; however, precipitators that achieve a collection efficiency of approximately 99.5 percent are currently available. The incremental energy requirement of a 99.5 percent efficient ESP compared to one with the degree of efficiency required by state standards is negligible. Data on the energy consumption of these units are presented in chapter 7. For a 1000-ton-per-day kraft mill direct-contact recovery furnace, the incremental capital cost for the more efficient ESP over a state standard is $460,000, and the incremental annual cost is $110,000. The incremental costs and the total costs are considered to be reasonable. Therefore, a precipitator with a collection efficiency of approximately 99.5 percent is considered to be the best method of emission reduction, considering costs.

Recovery Furnace Control System - The best demonstrated technology, considering costs, for controlling both TRS and particulate matter emissions from the recovery furnace is a 99.5 percent efficient precipitator and either a direct-contact black liquor oxidation furnace with two stage of black liquor oxidation and good combustion control in the furnace or an indirect-contact furnace with good combustion control in the furnace.

9.3.2 Smelt Dissolving Tank

The smelt dissolving tank is a source of both TRS and particulate emissions at a kraft pulp mill. The particulate matter is comprised of finely divided smelt particles that become entrained in the steam emitted from the tank. TRS emissions may be generated in either the dissolving tank itself or in the particulate scrubbing device, and strongly depend on the quality of water used either to dissolve the smelt or to carry out the scrubbing.

Particulate

Particulate emissions from the smelt dissolving tank are controlled by using either wire mesh demister pads with countercurrent washing, a low energy scrubber, or a combination of these two methods. The demister pads require very little energy to operate, the circulation of the washing water being the major factor. Consequently, the operating costs are very low. The second alternative, the scrubber, has been shown to be a more efficient control device, removing as much as five times the amount of particulate matter as a demister. The third alternative, the combination system, is similar in control efficiency and costs to the scrubber. The energy requirement for the scrubber is much greater than that for the demister, although small in comparison to total process energy requirements at a kraft pulp mill. The operating costs for this alternative are slightly higher. These costs, however, are considered to be reasonable.

TRS - TRS emissions are primarily caused by the presence of reduced sulfur compounds in the smelt and in the water used to dissolve the smelt. Since a portion of the TRS compounds is dissolved in the condensed vapor, TRS removal is related to the efficiency of the particulate collection device. When process water contaminated by sulfides and sulfates is used in the scrubber, reduced sulfur emissions can be stripped from the scrubber water and emitted to the atmosphere. These sources of emissions can be reduced at little cost by insuring that the water for dissolving smelt and the scrubber water are uncontaminated with dissolved sulfides. The best system of emission reduction for TRS emissions from this facility is the use of water that is not highly contaminated with dissolved sulfides from dissolving the smelt and for scrubbing. This requires no additional energy, and the costs for using water that is not highly contaminated are very low and considered reasonable.

Best Method for TRS and Particulate Emission Reduction

Cost, energy, water and solid waste impacts are not significantly different between the three systems considered. Therefore, emission reduction efficiency is the determining factor. The use of water that is not highly contaminated with dissolved sulfides for dissolving the smelt and in the scrubber and the use of a low energy water scrubber or a combination demister/low energy water scrubber is considered to be the best system of emission reduction, considering costs.

9.3.3 Lime Kiln

The lime kiln is a major source of both TRS and particulate emissions from a kraft pulp mill. Emissions from a poorly controlled facility may range to over 100 ppm TRS, and 4.0 lb/ton ADP for particulate matter.

Several alternative systems for the control of these emissions have been identified and studied in detail. These are summarized for a 1000 TPD model kraft pulp mill in Table 9.2, which outlines the control technologies that are considered to be most effective for the simultaneous removal of TRS and particulate matter. This allows

TABLE 9.2

COMPARISON OF THE ALTERNATIVE CONTROL SYSTEMS FOR THE LIME KILN SYSTEM

(1000 ton per day Kraft Pulp Mill)

Lime Kiln Control System	Process Controls	15" Venturi Scrubber	30" Venturi Scrubber	Caustic Addition	Electrostatic Precipitator	MAXIMUM GROUND LEVEL CONCENTRATION ($\mu g/m^3$) LIME KILN CONTRIBUTION ONLY (at distance from mill noted)		TOTAL INCREMENTAL ENERGY REQUIREMENT (10^6 Btu/day)	INCREMENTAL CONTROL COSTS (December 1975 dollars)		
						TRS (1-hour average)	PARTICULATE (24-hour average)		Capital Cost ($)	Annual Costs ($/yr)	Annual Cost per ton ($/ton)
1 Baseline	X	X				1.4 (400 m.)	7.9 (800 m.)	0	0	0	0
2	X		X	X		0.9 (650 m.)	4.0 (800 m.)	187	25,000	112,100	0.341
3	X		X			1.8 (650 m.)	4.0 (800 m.)	187	25,000	106,100	0.323
4	X				X	1.8 (650 m.)	1.3 (800 m.)	575	210,000	252,300	0.768
5	X	X		X	X	0.9 (650 m.)	1.3 (800 m.)	613	350,000	351,300	1.069

a point-by-point comparison to be made of all of the major factors that were considered in the selection of the best emission reduction system.

System number 1 was chosen as the baseline system with which the other alternatives are compared. This system is the type of control technology that is most often applied to lime kilns at existing mills: process control for limiting TRS emissions and a medium pressure drop scrubber, approximately 15 inches water gauge, for particulate control.

System number 2 is based on more effective control technology for both TRS and particulate matter emissions. A 30-inch water gauge pressure drop venturi scrubber is used to control the particulate emissions. More efficient process controls are applied to the operation to reduce the TRS emissions; the cold end temperature is raised as much as 100°F, while the proper O_2 concentration and temperature are maintained to provide better combustion conditions in the kiln. In addition, the efficiency of the mud washing that is used prior to the calcining process is improved. These improved process controls have been shown to have a significant effect on the concentration of the emitted TRS. In addition to the process controls for TRS reduction, a caustic solution is used in the scrubber. It has been demonstrated that the addition of the caustic to the scrubbing water has the capability of reducing the TRS emissions by as much as 10 ppm at the level expected from a well-controlled facility. This type of system is presently in use on at least two kilns in the U.S.

System number 3 is similar to system 2 and uses the same type of venturi scrubber and the same level of process controls. However, caustic is not added to the scrubbing fluid.

System number 4 uses the same process controls as system number 2 for control of TRS. However, the venturi scrubber is replaced with a high efficiency electrostatic precipitator (ESP), which provides a larger reduction of the particulate matter emissions. This system is presently used at only one U.S. mill.

System number 5 represents a proposed control technique that has not been applied in the industry. The system is a combination of the best parts of the preceding alternatives, combining the most effective process controls, caustic addition to a scrubber of 15 inches water gauge pressure drop, and an ESP with efficiency comparable to that used in system number 4. It is assumed that the scrubber and ESP can be installed in series with no major design difficulties, although this has not yet been demonstrated. A low pressure drop packed tower would probably give more contact and retention time than a venturi scrubber and is considered to be more effective in controlling a gas than a venturi scrubber.

The industry has commented that, if a lime kiln is controlled with an ESP, it may not be feasible to combust the off-gases from the digester system, multiple effect evaporator system, or condensate stripper system in the kiln; there would be a possibility of an explosion of the gases from these systems in the precipitator in the event of a flameout in the kiln. In such a case, a separate incinerator is required for the control of these gas streams. The energy requirements and incremental control costs for this unit are included in the table for systems 4 and 5.

The energy requirements and control costs for each alternative control system are also presented in Table 9.2. The incremental values with system number 1 used as the baseline are shown.

The energy requirements for emission control are higher for a system employing an ESP (systems 4 and 5). The amount consumed by the ESP itself is a small portion of the total. The majority of the consumption is the fuel requirement of the incinerator unit, the use of which is necessary with the ESP. The requirements are increased further when the venturi scrubber is added to the ESP in system 5.

The environmental impacts associated with the use of the alternatives have been evaluated and are discussed in chapter 7. The conclusion is that no significant water pollution or solid waste disposal problems will be incurred due to the use of these control devices.

Selection of Best System

In selecting the best system of emission reduction considering cost from these alternatives, the air, cost, energy, water, and solid waste impacts were considered. The water and solid waste impacts are negligible and therefore are eliminated as a basis for judgment. Each system that utilizes an ESP has a higher energy impact, a higher capital and annual cost impact and a higher impact on particulate matter reduction. Any system which uses a caustic scrubber without an ESP has a lower energy impact, a lower capital cost impact, a slight annual cost impact, a high TRS reduction impact, and a low particulate matter impact.

The best system of emission reduction not considering energy or cost is system 5 which employs the best of both the TRS and particulate matter technologies. In comparison to system 2, which uses the best TRS control, it uses about 85 percent more energy (approximately 7.9% of total process electrical and fossil fuel and energy requirement), is significantly more costly and reduces the particulate matter concentration slightly. System 2 was selected over system 5 because it is less costly, provides the same reduction of TRS emissions, and only slightly less particulate matter reduction. The Agency does not think that the additional cost and energy requirements are justified by the small increase in the reduction of particulate emissions.

Comparing system 2 to system 4, system 4 has a slightly higher particulate matter reduction impact, a lower TRS reduction impact, a significantly high capital and annual cost impact and an energy impact (an increase of less than 7.5% compared to mill process electrical and fossil fuel energy). System 2 was selected over system 4.

System 2 was selected over system 3 because system 3 has a significantly lower TRS reduction impact even though it has a slightly lower annual cost impact. Therefore, system 2 which includes a 30-inch caustic scrubbing system is considered to be the best system of emission reduction considering cost for the lime kiln, and the proposed standard is based on the level achievable by this method.

9.3.4 Digesters, Brown Stock Washers, Multiple-Effect Evaporators, Condensate Stripper and Black Liquor Oxidation System

Emissions from the digesters, brown stock washers, black liquor oxidation tanks, multiple-effect evaporators, and condensate strippers account for approximately 25 percent of the total amount of TRS released from an average kraft pulp mill. The emissions from these facilities are generally of a high TRS concentration and cause a substantial part of the localized odor problems associated with kraft pulp mills.

Control of these gaseous emissions has been well demonstrated at several sources by incinerating the gases in the recovery furnace, the lime kiln, and separate incineration units. With proper control of combustion conditions, the TRS can be oxidized, thus reducing TRS emission levels significantly from uncontrolled facilities. The cost impacts associated with this method of control are basically for the additional hooding, piping, and blowers required for collection of the gases and delivery piping and controls for the injection of the gases at the incineration point. Additional condensation equipment may also be required for the handling of the vent streams from the brown stock washers and the black liquor oxidation system. The streams from these two facilities are often very moisture laden and must be condensed prior to incineration in the recovery furnace.

Utilization of the non-condensables from the brown stock washers and the oxidation tanks may require additional fuel consumption at the point of incineration, usually the recovery furnace. Incineration of the non-condensable gases from the other three facilities would not require additional fuel if they are burned in the lime kiln as part of the primary air feed.

A few facilities have been observed that are controlled by various types of scrubbing systems. These systems are much less efficient than incineration and incur an added energy impact. Scrubbing is not considered to be the best method of emission reduction considerng cost.

Incineration is applicable to all five of the affected facilities and has no significant water, solid waste, or energy impacts. TRS emissions are significantly reduced by incineration so there is a positive air impact, and the cost is considered to be reasonable. Therefore, incineration is considered to be the best method of emission reduction considering cost for these five TRS emission sources.

9.3.5 Best System of Emission Reduction Considering Cost for a Kraft Pulp Mill

The best system of emission reduction for a kraft pulp mill, is a collection of the best systems identified in section 9.3 for each of the affected facilities. This system includes the following methods of improved process operation, types of process equipment and types of control equipment:

Recovery Furnace - System	Process control, indirect contact evaporator, and ESP; or alternatively, process control, direct contact evaporator with additional black liquor oxidation and ESP.

Smelt Dissolving Tank - Use of water that is uncontaminated with sulfides for dissolving smelt and in the water scrubber, and a low energy water scrubber.

Lime Kiln - Kiln process controls, more efficient lime mud washing, and a 30 inch water gauge pressure drop venturi scrubber with caustic addition.

Other Sources: Black liquor oxidation, system brown stock washer system, multiple-effect evaporator system, condensate stripper system, and digester system - Collection of fumes and incineration in lime kiln, recovery furnace or separate incinerator.

The cost for the aggregate of these systems for each facility has been evaluated in chapter 8, and the total costs are considered reasonable. Therefore, this is the best system of emission reduction for a kraft pulp mill, considering cost, and the proposed standards are based on this system.

9.4 SELECTION OF THE FORMAT OF THE PROPOSED STANDARDS

Standards for kraft pulp mills could be expressed in terms of either mass emissions per unit of production or a concentration of pollutant in the effluent gases. The most common format now used by the industry and state control agencies is pounds of pollutant per ton of air-dried unbleached pulp produced (lb/T ADP). This format offers the advantage of preventing circumvention of the standards by the addition of dilution air or the use of excessive quantities of air in process operations. The principal disadvantage is that a control agency cannot readily or accurately measure the pulp production over the short term. Due to storage capacity of the mill, the recovery furnace, smelt dissolving tank, lime kiln, concentrate strippers, black liquor oxidation tanks, and multiple-effect evaporators can be operating on accumulated inventories when the digesters are off stream (no pulp production). Similarly, the above facilities can be operating below capacity even though the pulp production may be at design rates.

9.4.1 Particulate Standards

Concentration units are recommended as the format for the proposed particulate standards for the recovery furnace and lime kilns. The reasons for this decision are outlined below:

a. Concentration units can be corrected for excess oxygen in the lime kiln and recovery furnace exhaust streams, precluding circumvention of the standards by dilution.

b. Only precise measurement of emissions and gas velocities are required to determine compliance with a concentration standard; therefore, accurate measurement of production of feed rates is not required.

c. Most of the data (EPA, state and local control agency, and company data) which are used to support the proposed standards are in the format of concentration units. The bases used by operators and control agencies to convert from concentration to lb/ADP in many cases are not consistent and are not clearly defined. Converting the data to another basis could introduce substantial inaccuracies.

The format for the proposed particulate matter and TRS standards for smelt dissolving tanks is discussed under section 9.4.3.

9.4.2 TRS Standards

Concentration units are also recommended as the format for the proposed TRS standards for the digesters, the brown stock washers, the black liquor oxidation system, the multiple-effect evaporators, the recovery furnace, the lime kiln, and the condensate stripping system. The reasons for the selection of this format are outlined below:

a. Same as a. and c. under the previous section for particulate standards format.

b. The reference test method for TRS reads out data in concentration units. No conversion factors are therefore required in determining compliance for the affected facilities.

c. Average concentrations are proposed rather than instantaneous concentrations to allow for fluctuations in emissions which occur even during periods of normal operation.

Four hours was chosen as the averaging period in order to allow a sufficient number of test readings to be taken. The proposed reference test method, gas chromotography, requires readings to be taken at 15-minute intervals. A 4-hour average would allow enough readings (sixteen) to make some allowance for short-term emission peaks, while being short enough to allow for a reasonable testing period.

d. Commercially available continuous monitors that may be used to measure emissions from these facilities indicate concentration directly. A direct indication of performance of the control systems would be available, and therefore the operator would be aware of excess emissions that require corrective action.

9.4.3 Standards for Smelt Dissolving Tanks

The proposed particulate and TRS standards on smelt dissolving tanks are expressed in grams per kilogram ADP (g/Kg ADP) to prevent circumvention by dilution. EPA tests show that gas volumes from existing smelt tanks vary in exhaust concentrations by a factor of as much as 2.5 even though the smelt dissolving tanks have the same mass emission rate (g/Kg ADP). Dilution cannot be prevented by correcting for excess oxygen because the exhaust stream discharged from the smelt dissolving tank is mostly ambient air.

9.5 SELECTION OF THE EMISSION LIMITS

Limitations for control of emissions of TRS and particulate matter are set to the level attainable using the best demonstrated technology, considering costs, for each affected facility. This control technology is identified in section 9.3. The purpose of this section is to quantify the proposed standards by specifying the emission limits. The rationale for selecting the proposed standards over alternative emission levels is presented in this section.

In section 9.4 the format of the proposed standards is discussed. Concentration standards for TRS and particulate matter for all affected facilities excepting the smelt dissolving tank are proposed in ppm and g/dscm, respectively. The proposed TRS and particulate standards for the smelt dissolving tank are in terms of mass per unit of production (g/Kg ADP).

A presentation of the emission data that were gathered during the source testing program is summarized in chapter 6. A description of the facilities tested and all pertinent information relative to the operation of testing of each facility is included. A complete summary of all the tests is presented in Appendix C.

9.5.1 Recovery Furnace

As discussed in section 9.3.1, two classifications of recovery furnaces in use in the kraft pulping industry today are (1) the conventional system which uses a direct contact evaporator and requires oxidation of the black liquor, and (2) the newer system which uses an indirect-contact evaporator. Good control of combustion is necessary to maintain the best levels of TRS control. Best demonstrated particulate control for both systems is achieved by the use of a high efficiency ESP.

Particulate Emissions

Four recovery furnaces were tested by EPA for particulate emissions: two direct contact systems and two indirect contact systems. All four systems are controlled by electrostatic precipitators, with design efficiencies of 99.5 to 99.8 percent.

Furnace J has two stacks, both of which were tested by EPA. Stack J" had emissions higher than would normally be expected from the design efficiency, and much higher than stack J'. Both precipitator systems were of equal design and each handled approximately 50 percent of the exhaust flow. Upon investigation it was found that precipitator J" was probably not operating in a normal manner during the test. The turning vanes and air distribution plates were caked with particulate salt, resulting in improper air patterns within the precipitator and reduced collection efficiency. The unit had not been recently cleaned, as had unit J', and there was no cleaning mechanism operating on the precipitator during the tests. The results of six test runs on this unit showed an average concentration of 0.12 g/dscm (0.054 gr/dscf), well above the levels measured on stack J'. The remainder of this section deals only with the results of the valid stack tests.

The average of the remaining tests was 0.03 g/dscm (0.013 gr/dscf). The range of the individual test runs was 0.01 to 0.08 g/dscm (0.008 to 0.035 gr/dscf). The proposed standard for particulate matter emissions from the recovery furnace is 0.10 g/dscm (0.044 gr/dscf), a level adequately substantiated by the emission tests. Both types of furnace systems have been shown to be capable of meeting this emission limit. With proper maintenance of the wires, collection plates, and rappers, the efficiency of the control system can be maintained at this level.

As discussed in section 9.3, precipitator performance may deteriorate due to broken wires and poor air distribution within the precipitator. This may gradually occur over periods of 12 to 18 months of normal operation, at which time maintenance of the unit will result in a return to the design efficiency. The level of 0.10 g/dscm (0.044 gr/dscf) will require that the best system of emission reduction, considering costs, to be properly operated and maintained.

TRS Emissions

TRS emissions were tested from three recovery furnaces: two direct contact systems and one indirect contact system. The two direct contact systems employ black liquor oxidation for reduction of TRS from the furnace. Proper combustion parameters are maintained to control emissions from the furnace firing process on both types of systems. The emissions tested from these two facilities ranged from about 1 ppm to 7 ppm, and averaged about 3 ppm (4-hour averages). The test data from the one indirect contact system averaged about 0.6 ppm. The range of the individual test runs was 0.2 to 1.6 ppm (4-hour averages).

Oxygen Correction

The oxygen content of the flue gas measured during the tests varied between 5 and 10 percent. Measurements of the concentration in the gas stream before and after the precipitator indicate that leakage into the unit can be expected, thus diluting the particulate concentration. Although regulations prohibiting circumvention of the concentration standard by dilution are in effect, it is difficult to distinguish between process air and dilution air. Therefore, some provision is needed to correct for excess air inleakage in the outlet stream. When the oxygen concentration exceeds 8 volume percent O_2, the correction will be made down to 8 percent. Well operated and controlled furnace and precipitator systems will normally operate below 8 percent O_2, so corrections will not be required in every case.

In summary, the emission test data show that both types of furnace systems are capable of achieving TRS concentrations below 5 ppm on a four-hour average. TRS emissions fluctuate over long periods and may exceed the 2 to 3 ppm averages reported. These variations are unaccountable in terms of furnace operation, but must be taken into consideration in the selection of the emission limit. The chosen level of 5 ppm (4-hour average, corrected to 8 volume percent O_2 when the concentration exceeds 8 percent) reflects the levels that are achievable, while allowing for some variation in emissions over a four-hour period. This 5 ppm level will also allow flexibility in the choice of furnace system to be used.

9.5.2 Smelt Dissolving Tank

The use of a low energy scrubber with uncontaminated water in the tank and scrubber column was identified as the best emission control system, considering costs for this facility. This type of system was tested by EPA on two facilities for particulate matter and two facilities for TRS.

The format for the proposed standards for this facility is discussed in section 9.4. A mass per unit of production format, g/Kg ADP, is proposed to prevent circumvention of a concentration standard due to the large amount of process air normally present.

Particulate Emissions

The data for particulate emissions from the four units tested ranged from about 0.05 to 0.22 g/Kg ADP. The average of the test runs was approximately 0.13 g/Kg ADP. Emissions from these facilities vary over long periods of operation. By proposing the standard at 0.15 g/Kg ADP, this fluctuation is taken into account while still requiring the use of best demonstrated technology, considering costs.

TRS Emissions

Two smelt dissolving tanks were tested for TRS emissions, yielding results of 0.004 and 0.008 g/Kg ADP. Twelve facilities were tested by the National Council of the Paper Industry for Air and Stream Improvement (NCASI) showing values ranging from less than 0.001 to 0.06 g/Kg ADP. The higher data, however, are from tests on facilities that do not use the best control system previously outlined. But the results indicate that there is a large range of variation in emissions from even well controlled facilities. The proposed emission limit of 0.0125 g/Kg ADP requires that the most efficient control system be used, while allowing for some degree of variation in the emissions.

9.5.3 Lime Kiln

The proposed standards are based on control of TRS and particulate emissions from the lime kiln through good process controls, use of a 30-inch pressure drop venturi scrubber, and addition of a caustic solution to the scrubbing water. A detailed discussion of this technology is in chapter 4, and the reasons for its selection as the best demonstrated technology, considering costs, is presented under section 3 of this chapter.

Particulate Emissions

EPA performed tests for particulate emissions on four lime kilns. Emissions from each kiln were controlled by a venturi scrubber, with a range of pressure drops of 15 to 33 inches water gauge. Where possible, separate tests were performed while the kilns were burning oil and natural gas; it was noted that the particulate emissions were much higher when fuel oil was burned. The test results are presented in chapter 6 along with a short discussion of each facility tested. A complete summary of each test run is presented in Appendix C.

Tests on Kiln D show very high emissions, not considered representative of control with best demonstrated technology. These results were presented to show the range of emissions encountered during the test program. The data were not used in the selection of the emission limits for lime kiln particulate emissions.

Tests on the three remaining kilns show that much lower emission concentrations are achievable. When burning natural gas as fuel, particulate test runs showed a range of 0.05 to 0.15 g/dscm (0.022 to 0.066 gr/dscf) and an average of about 0.09 g/dscm (0.04 gr/dscf). Emissions were higher when oil was burned instead of gas. Tests on Kiln L were particularly high, averaging 0.548 g/dscm (0.24 gr/dscf). It was concluded that these high concentrations resulted from incomplete combustion of the oil. These results were not used in the selection of the emission limits. The results of the remaining two tests showed individual runs ranging from 0.07 to 0.29 g/dscm (0.03 to 0.13 gr/dscf). The average of the five runs was 0.10 g/dscm (0.04 gr/dscf). When during any of the above reported tests the oxygen content of the exhaust stream exceeded 10 volume percent, the measured emissions were corrected to 10 percent O_2.

TRS Emissions

Tests on three lime kilns for TRS emissions show a range of from less than 1 ppm to about 24 ppm, on a four-hour average. Two facilities are controlled through application of good process controls. Emissions from Kiln D averaged 9.8 ppm (four-hour average) over six test runs. Emissions from Kiln K averaged about 6 ppm (four-hour average) also over six runs. In both cases, fresh water was used as makeup to the scrubbers for particulate control, and the sulfide content of the lime mud was quite low, between 0.3 and 0.4 percent. Noncondensable gases from the digester system, the multiple-effect evaporators, or turpentine recovery system were burned in the kilns during the tests.

Six test runs on Kiln E resulted in a range of four-hour average emissions of 0.3 to 1.7 ppm, averaging 0.7 ppm. TRS emissions are controlled at this kiln by maintaining good process controls and by adding a sodium hydroxide solution to the fresh scrubbing water.

Further test data were supplied by the mill that operated the caustic scrubber to give an indication of the variations in the emission concentrations over a longer period of time. The period selected was 30 days, which included the time when the EPA source tests were performed. Data were continuously monitored and recorded with a coulometric titrator manufactured by ITT-Barton, which was operated according to the specifications set by the manufacturer.

EPA analyzed the data for the entire 30-day period excluding periods of start-up, shutdown, and malfunction. Readings were recorded every 15 minutes in order to compute 1-hour averages and then 4-hour averages. When any point within a specific one-hour period exceeded 5 ppm TRS, a manual integration was performed using a planimeter. The four-hour averages were computed using both of the data sets. A summary of the data analysis is presented in Tables 9.3 and 9.4.[9]

The analysis shows that for the period under consideration, the four-hour average TRS concentration exceeded 5 ppm only 6 percent of the time, and the maximum four-hour average did not exceed 10 ppm. A twelve-month period which includes the month of data analyzed by EPA was reported by the mill operator to have a total of 58 such excursions above 5 ppm TRS. This total, however, included emissions during periods of start-up, shutdown, and malfunction, and must be reduced to reflect the number of excursions during periods of normal operation. At least 12 excursions must be subtracted from the total; this leaves 46 excursions, which is an average of less than 4 per month. Therefore, it is probable that the period of operation analyzed by EPA represents a month in which excursions were more numerable than usual. Since the

TABLE 9.3

Lime Kiln E
Distribution of TRS Data
Four-hour Average Concertrations
September 1 - October 1, 1973

4-Hour Average* ppm	Number of Readings Exceeding Average	Percent of Total Exceeding Average
0	96	57.1
1	31	18.5
2	13	7.7
3	9	5.4
4	6	3.6
5	8	4.8
6	2	1.2
7	2	1.2
8	1	0.6
9 - 26	0	0
Totals	168	100.1 (rounding off error)

*Four-hour averages calculated from strip chart readings taken every 15 minutes.

TABLE 9.4

Lime Kiln E
Distribution of TRS Data
Four-hour Average Concentrations
September 1 - October 1, 1973

4-Hour Average* ppm	Number of Readings Exceeding Average	Percent of Total Exceeding Average
0	96	57.1
1	28	16.7
2	16	9.5
3	13	7.7
4	5	3.0
5	5	3.0
6	1	0.6
7	2	1.2
8	1	0.6
9	1	0.6
10 - 26	0	0
Totals	168	100.0

*Four-hour averages calculated from combination of strip chart readings taken every 15 minutes and planimeter integration determinations where > 5 ppm excursions occurred.

monitoring specifications for TRS monitors have not yet been developed, it is not known for certain whether the monitoring instrument used to obtain this data will meet these specifications. The TRS continuous monitoring system specifications are expected to be proposed in the near future. A standard of 10 ppm (four-hour average) was considered as an alternative to allow for these few excursions above 5 ppm. However, a standard of this level would not require the use of the best system of emission reduction, considering costs, and was therefore rejected. The proposed requirements for reporting excess emissions will, as discussed under section 9.8 of this chapter, accommodate an appropriate rate of excursions above 5 ppm as a part of normal operation. Further, the probability that a performance test will demonstrate emissions above 5 ppm TRS is less than indicated above because compliance will be based on the average of three runs of the reference test method for TRS emissions.

Oxygen Correction

Lime kilns normally operated with exhaust end oxygen concentrations below about 10 volume percent. The O_2 concentrations measured in the emissions from the three lime kilns tested for TRS ranged from 2.5 to 7 volume percent; those from the three kilns tested for particulate emissions ranged from 1.9 to 11.5 percent. To avoid excess dilution, the particulate and TRS concentrations measured in lime kiln emissions should be corrected to 10 volume percent O_2, when the actual concentration exceeds 10 percent. The data obtained during tests with O_2 concentrations exceeding 10 percent have been corrected to that baseline.

Selection of the Emission Limits

The proposed standards for the lime kiln system, based on the best system of emission reduction, considering costs, are therefore as follows:

Particulate matter

0.15 g/dscm when burning natural gas, corrected to 10 volume percent oxygen when the actual oxygen content exceeds 10 percent.

0.30 g/dscm when burning fuel oil, corrected to 10 volume percent oxygen when the actual oxygen content exceeds 10 percent.

TRS

5 ppm (four-hour average), corrected to 10 volume percent oxygen when the actual oxygen content exceeds 10 percent.

9.5.4 Digester System, Brown Stock Washers, Black Liquor Oxidation System, Multiple-Effect Evaporator System, and Condensate Stripper Column

The best control technology, considering costs, for these five sources of TRS is incineration. This incineration can be accomplished in the recovery furnace, the lime kiln, and a separate incineration unit. Maintenance of proper combustion parameters, basically temperature and residence time, will assure complete oxidation of the gases.

Test data on one incineration unit, burning non-condensable TRS gases from the digester system and multiple-effect evaporator system, show that levels ranging from 0.5 to 3 ppm (4-hour average) are achievable. The incinerator was operating at 1000°F with a retention time for the gases of at least 0.5 seconds. Similar results can be expected when the TRS gases are incinerated in either the recovery furnace or lime kiln. Tests on one recovery furnace in which gases from the brown stock washers were being incinerated indicate no effects on the performance of the furnace. Tests on lime kilns that were burning gases from the digesters, evaporators, condensate strippers, and miscellaneous storage tank vents indicate similar results.

The proposed TRS standards for these five affected facilities are set at 5 ppm (4-hour average). A concentration standard was chosen as the format of the proposed standards for the reasons presented in section 9.4. Test data support these proposed limits and show that incineration, the best control technique, considering costs, would be required to achieve the proposed standards.

9.6 VISIBLE EMISSION STANDARDS

The opacity of visible emissions is a measure of mass concentration of some pollutants. Various studies have shown that opacity varies directly with mass concentrations of particulate matter. The applicability and enforcement of opacity standards related to particulate matter have been established in several court cases for facilities subject to new source performance standards under section 111 of the Clean Air Act.

Opacity standards help to assure that sources and emission control systems are properly maintained and operated so as to comply with mass emission standards on a continuing basis. Opacity test methods are quicker, easier to apply and less costly than particulate concentration/mass tests. EPA considers opacity standards to be a necessary supplement to particulate mass emission standards and, therefore, opacity standards are established as independent enforceable standards.

Where opacity and concentration/mass standards are applicable to the same source, EPA establishes opacity standards that are not more restrictive than concentration/mass standards. The opacity standard is achievable if the source is in compliance with the concentration/mass standard.

Visible emission data were obtained during the development of the proposed standards at three recovery furnaces, three smelt dissolving tanks, and at one lime kiln during the time that particulate emission tests were being performed.

Recovery Furnace System

Visible emissions data were obtained during four tests of three recovery furnace systems that were using electrostatic precipitators. All of the opacity data were obtained as specified in EPA Reference Method 9. Over 900 six-minute average opacities were obtained that ranged from a low of 0% opacity at a mass concentration of 0.02 g/dscm to a high of 50% opacity at a mass concentration of 0.11 g/dscm. The concentration/mass standard that has been established to reflect best demonstrated technology considering costs for particulate matter control of kraft recovery furnace systems is 0.10 g/dscm (0.044 gr/dscf). A least squares fit of all the opacity/particulate concentration data collected during the emission measurement program shows that, on the average, a mass concentration of particulate matter of 0.10 g/dscm corresponds to approximately 27% opacity. Taking the variability of the 6-minute averages into consideration and normalizing all data to a three-meter diameter stack, the plus 95% confidence value of opacity at the level of the proposed mass concentration is approximately 35% opacity. Since the data were obtained by Reference Method 9, they include observer error. A discussion of the data analysis is given in chapter 6.

The options considered were setting the standard at: (1) the average level of opacity that corresponds to the proposed mass concentration, (2) the plus 95% confidence level which considers variations in 6-minute averages, (3) and at the plus 99% confidence level which also considers variations in 6-minute averages. The plus 95% confidence level was chosen because: (1) the average opacity would frequently be exceeded even when the particulate matter standard is being met;

(2) the 99% level would probably not ensure proper operation and maintenance of control equipment; and (3) infrequent excursions above the 95% level can be accommodated for monitoring and compliance purposes by proper definition of excess emissions and by collecting a sufficient amount of data when checking compliance. Therefore, the opacity standard that is proposed is 35% opacity as measured by Method 9.

The majority of the existing recovery furnaces in the industry use a continuous soot blowing cycle. According to a furnace vendor, most new furnaces will also use a continuous soot blowing cycle. For some smaller furnaces it is more economical to blow soot periodically, but the cost of alternative continuous blowing is considered reasonable. The proposed standard is based on opacity data from furnaces that use continuous soot blowing.

Smelt Dissolving Tank

Data were obtained on three of the smelt dissolving tanks tested for particulate emissions by EPA. However, the data for each smelt tank were obtained over two or more periods of observation for a total observation time of only about one hour. The steam plumes associated with these smelt tanks made it difficult to obtain readings on the residual plumes since the plumes tended to mix with other plumes in the mill prior to the dissipation of the steam. Therefore, these data are not considered sufficient to support a visible emission standard. Based on these observations, EPA believes that an opacity standard would in most cases be ineffective. Therefore, no opacity standard is proposed for this facility.

Lime Kilns

Visible emissions data were obtained on only one lime kiln tested for particulate emissions by EPA. The data from this one lime kiln are not considered sufficient to support a visible emission standard. EPA was not able to obtain opacity data on the residual plumes of the other lime kilns tested because the plumes mixed with other plumes in the mill prior to the dissipation of the steam. As with smelt dissolving tanks, EPA has concluded that an opacity standard for lime kilns would be ineffective in most situations. Accordingly, no opacity standard is proposed for lime kilns.

9.7 MODIFICATION AND RECONSTRUCTION CONSIDERATIONS

The proposed standards would apply to all affected facilities within a kraft pulp mill that are constructed or modified after the date of proposal of the standards. Changes that could possibly be considered as modification or reconstruction were presented in Chapter 5 along with explanations as to the choice of these types of changes.

The purpose of this section is to identify any exemptions or special allowances that should be incorporated into the proposed standards covering changes to facilities that could be considered as modifications or reconstructions. The following physical changes and changes in method of operation were considered:

(1) Conversion of a direct-contact furnace system to an indirect-contact system.

(2) Conversion of a lime kiln from burning natural gas to burning oil.

(3) Adding an additional stage of washing capacity to an existing brown stock washer system.

There appears to be no reason for excluding any of the above physical changes or changes in method of operation from the modification and reconstruction provisions of new source performance standards. In all cases the costs associated with the modification or reconstruction are judged to be affordable. The bases used for judging the affordability of each case are presented in detail in chapter 8, Economic Impact. No special allowances or exemptions are therefore proposed for these cases.

Most recovery furnaces at existing kraft mills are not designed to accept gaseous emissions from brown stock washer systems and black liquor oxidation systems. If a brown stock washer or black liquor oxication system are modified, reconstructed, or replaced, then the gases from these facilities would have to be controlled as required by the proposed standards. In this case it would mean that these gases would have to be incinerated in a separate incinerator. This is very costly and requires a significant amount of fuel. For these reasons new and modified black liquor oxidation and brown stock washer systems located at an existing kraft mill where the gaseous emissions from these facilities cannot be incinerated in an existing recovery furnace because of technical or economic reasons are exempted from the proposed standard until the furnace is modified, reconstructed or replaced so that the gases can be incinerated.

The industry has expressed concern about the proposed standard covering any black liquor oxidation systems at existing plants. Their contention is that it is a method of controlling TRS emissions from the recovery furnace and since black liquor oxidation systems always result in controlling more TRS emissions than they create, they should never be covered at existing plants. The proposed standard accommodates their concerns for the most part.

According to the industry, very few mills do not have at least one stage of oxidation. Therefore, most of the black liquor oxidation system construction will be additions to existing stages. This will be a modification because of the way that the affected facility is defined for black liquor oxidation systems. Therefore, the increased emissions of TRS from the added black liquor oxidation tank can be traded off. If a plant would replace an existing black liquor oxidation system or if one is installed at an existing plant that previously had none, then the black liquor oxidation system will be covered only if the black liquor oxidation system gases can be incinerated in the existing furnace. According to vendors and the industry, most existing furnaces are not designed to accept black liquor oxidation system gas streams. Whenever the existing furnace is modified, reconstructed, or replaced with a furnace that can accept these gases, then the black liquor oxidation system gases must be controlled. All black liquor oxidation systems at new mills must be controlled.

It is EPA's judgment that these provisions for the modifications or reconstructions of black liquor oxidation systems are reasonable.

9.8 SELECTION OF MONITORING REQUIREMENTS

Under section 114(a) of the Clean Air Act, the Administrator may require the owner or operator of an emission source to install, use, and maintain monitoring equipment or methods. EPA has exercised this authority to require for new source performance standards the monitoring of pollutant emissions or parameters that are indicators of pollutant emissions. The monitoring requirements are necessary to determine whether an affected facility is being operated and maintained properly and also to aid in determining whether a performance test should be required. The costs of installing and operating the monitoring systems and devices discussed below are considered reasonable.

TRS Stack Gas Monitoring

The volume concentration of TRS emissions can be monitored by use of monitoring systems that meet the proposed instrument performance specification. There are no process or control device parameters that are indicators of concentrations of TRS emissions from recovery furnace systems and lime kilns. Therefore, the gas stream TRS monitoring system is the only method of monitoring concentrations of TRS emissions from these affected facilities, and a requirement for monitoring of TRS concentrations from the lime kiln and recovery furnace is proposed. The continuous monitoring system specifications for TRS monitors are being developed and it is expected that they will be proposed in the near future and be promulgated with the kraft mill standards.

Since the standard for smelt dissolving tanks is expressed in a format of pollutant mass per unit of production, the gas flow rate and the production rate would have to be measured simultaneously to reduce the TRS concentrations measured by the monitor to units of the proposed standard. Inaccuracies would arise from measuring velocities continuously, and the production rate cannot be measured accurately except over relatively long periods of time. The inaccuracies involved in continuously measuring emissions from the smelt dissolving tank are felt to be sufficiently large that EPA has determined that the direct monitoring of TRS emissions from the smelt dissolving tank is not practical.

Another method exists for continuously monitoring the proper operation of smelt dissolving tanks to ensure that TRS emissions are well controlled. TRS emissions from the smelt dissolving tank are related to the concentration of dissolved sulfides in the smelt dissolving water and in the water used in the scrubber. The concentration of the dissolved sulfides could be monitored, but neither EPA nor the industry have experience with this type of monitoring. The proposed standards therefore do not require the monitoring of dissolved sulfides in the smelt dissolving water or the scrubber water.

TRS concentrations in the effluent gases from an incinerator that controls TRS emissions can be measured by a continuous monitoring system. However, there are less costly means of monitoring the proper operation of incinerators that control TRS emissions.

An EPA test and previous work done on incinerators for kraft pulp mill TRS control have shown that TRS concentrations do not exceed 5 ppm if a temperature of 1000°F and a residence time of at least one-half second in the fire box are maintained. Incinerators are designed for a particular residence time that will not be reduced if the incinerator is not operated above its designed capacity. While it is very cumbersome and costly to measure the parameters that are necessary to determine the fire box residence time, the fire box temperature is readily measured and recorded. EPA has concluded that continuously measuring and recording the fire box temperature is an effective alternative method of monitoring the TRS concentrations. If non-condensable gases from facilities that are covered by the standard are incinerated in the recovery furnace or the lime kiln, the TRS monitoring system on the furnace or the lime kiln will serve to monitor the sources that are being incinerated.

Particulate and Visible Emissions Monitoring

Opacity monitors are available that meet EPA's published specifications for continuous monitoring systems. These monitors were considered for measuring the opacity of emissions from recovery furnace systems and lime kilns. Opacity monitoring systems on recovery furnaces are well demonstrated. Therefore, the use of a continuous monitoring system is proposed as a requirement for the recovery furnace.

EPA and industry have no experience with opacity monitors on lime kilns. The reason for this is that since most lime kilns use scrubbers, the interference caused by entrained water droplets causes an error that cannot be corrected. Therefore, the data obtained by the monitoring system would be questionable. The Agency is therefore not requiring the continuous monitoring of opacity from lime kilns.

There are other methods of monitoring the proper operation and maintenance of particulate control devices on lime kilns which are discussed below.

Opacity monitoring systems cannot be applied to the smelt dissolving tank because of entrained water and condensed steam that are present.

The device used most frequently to control emissions from a lime kiln is a venturi scrubber. The pressure drop for the venturi scrubber and the liquid flow rate are indicators of the performance of the scrubber. Instead of requiring the use of a continuous opacity monitoring system, the proposed regulations require the use of monitoring devices for continuous monitoring of the pressure loss through the venturi constriction and the scrubbing liquid supply pressure to the control device. The performance of the scrubber would therefore be monitored by comparing the values of the pressure parameters with the values at the time the performance test for particulate emissions was performed.

The continuous monitoring of the pressure drop and water flow rate for the low energy pressure drop scrubber used to control particulate matter from the smelt dissolving tank is required to determine if the scrubber is being properly operated.

Oxygen Monitoring

The proposed TRS and particulate concentration standards for the lime kiln and the recovery furnace are corrected to 10% and 8% oxygen concentration, respectively, when the oxygen concentration is above these levels. The reason for this is that the excess air used in the combustion process and the air inleakage into the gases from these facilities vary and a correction to an oxygen concentration level is needed. It is EPA's judgment that an oxygen concentration of 8 volume percent for the recovery furnace and 10 volume percent for the lime kiln represent excessive process air dilution of the gas stream. Therefore, the proposed standards require that the concentrations of particulate matter and TRS from the recovery furnace and lime kiln be corrected to 8 and 10 volume percent oxygen when the oxygen concentrations are above these levels. It is proposed that an oxygen monitor be installed downstream of the control device so that the TRS concentrations that are measured from the lime kiln and recovery furnace can be corrected to 10% and 8% oxygen, respectively, when the actual oxygen concentrations are above these levels for the purpose of determining excess emissions. The oxygen monitor must measure the oxygen concentration on a dry basis. The specifications for the oxygen monitoring system were promulgated on October 6, 1975 (40 FR 46240).

Excess Emissions

As specified in section 60.7(b) and (c) of the regulations (Notification and Recordkeeping), the operator of any source subject to the proposed standard would be required to maintain records of the occurrence and duration of any start-up, shutdown, or malfunction in the operation of an affected facility, any malfunction of the air pollution control equipment, or any periods during which a continuous monitoring system or monitoring device is inoperative. All excess emissions due to malfunctions, start-ups or shutdowns, and other excess emissions as defined in each applicable subpart, must be reported to EPA for each calendar quarter. Generally, excess emissions are defined in terms of the applicable standards. For example, if the standard for a particular facility is 5 ppm of TRS, four-hour average, then excess emissions would usually be defined as all occurrences during the quarter for which 5 ppm TRS, four-hour average, was exceeded. In some special cases where excess emissions can be predicted to normally occur at a well operated facility for a small percentage of the time, this is reflected in the definition of excess emissions. The definition of excess emissions for each affected facility at a kraft mill is discussed below.

Recovery Furnace Systems

Excess emissions of TRS from a recovery furnace are defined as all four-hour averages of TRS concentrations above 5 ppm. EPA data indicate that a well operated plant applying best technology will not exceed a concentration of 5 ppm on a four-hour average basis.

Excess emissions of opacity from a recovery furnace are defined as all six-minute average opacities that exceed 35 percent, except 5 percent of all the 6-minute averages except those which occur during start-up, shutdown, or malfunction of the facility or control device. EPA's analysis of Method 9 data indicates that there is a 5 percent probability that a six-minute average opacity will exceed 35 percent when the stack gas emissions are equivalent to the mass emission standard. It is the Agency's judgment that Method 9 data are more variable than transmissometer data. Therefore, this data will not be more restrictive when applied to transmissometer data obtained during monitoring.

Lime Kiln

Excess emissions of TRS from a lime kiln are defined as all four-hour average TRS concentrations above 5 ppm except that 6 percent of all four-hour averages of TRS concentrations except those which occur during start-up, shutdown or malfunction of the facility and control device are not considered to be excess emissions if they are less than 10 ppm. EPA analyzed one month of continuous TRS monitoring data from a plant that uses the technology on which the standards are based. The data analysis showed that when the facility and control system were properly operated and maintained there were no four-hour average TRS con-entrations that exceeded 10 percent, and 6 percent of these four-hour average concentrations were greater than 5 ppm. Therefore, the excess emissions were determined on the basis of these data.

Incineration

Excess TRS emissions from the incineration of gases from affected facilities other than lime kilns, recovery furnaces, or smelt dissolving tanks are defined as all TRS concentrations that exceed 5 ppm on a four-hour average. EPA has concluded that a well operated incinerator applying best technology will not exceed 5 ppm on a four-hour average basis except during malfunctions, start-ups and shutdowns.

9.9 SELECTION OF PERFORMANCE TEST METHODS

Test methods for the measurement of particulate matter and TRS emissions from kraft pulp mills are proposed for determining compliance with the proposed standards. EPA Reference Method 5 would be used for the measurement of particulate emissions. Reference Method 16, "Semicontinuous Determination of Sulfur Emissions from Stationary Sources," which is being proposed concurrently with the standards, would be the reference test method for the measurement of total reduced sulfur (TRS). The performance test methods are discussed in detail in Appendix D.

Reference Method 16 was developed specifically for the test program during the development of the proposed TRS standards for kraft pulp mills. Several alternative methods were considered including colorimetry, spectrophotometry, coulometry, and gas chromatography. The colorimetric method suffers from limited test ranges, variable collection efficiency, and sensitivity to light and humidity. The use of infrared and mass spectrophotometry were considered expensive, time consuming, and not suitable for routine field applications. Split beam ultraviolet spectrophotometry, more promising for application to kraft pulp mills, was rejected because of a low end accuracy of 10 ppm, higher than emissions expected from well controlled facilities. Coulometric titration has been widely used in the kraft pulping industry as a continuous monitor. The use of this method as a performance test did not appear to be as promising, due to the lesser sensitivity of the unit compared to gas chromotography. The gas chromotography (GC) method, combined with analytical determination by the flame photometric detector (FPD) has a sensitivity of less than 5 parts per billion, well below the levels expected from well controlled facilities. Interfering components, carbon monoxide and moisture, can be selectively removed with a stripper column. The GC/FPD method, due to the better sensitivity of measurement and ease of application to gas streams in kraft pulp mills, was chosen as the best system for the measurement of reduced sulfur compounds at kraft pulp mills.

In addition to Method 5 and Method 16, Reference Method 2 for velocity and volumetric flow rate, Reference Method 3 for gas analysis, and Reference Method 9 for visible emissions would be used to determine compliance. These Reference Methods have been applied to other categories of stationary sources for which new source performance standards have been developed, and have been published in Appendix A to Part 60.

Method 17 is also being proposed as an alternate test method for the measurement of particulate emissions from recovery furnaces at kraft pulp mills. This method involves the use of an in-stack filter, a simpler operation than that prescribed in Method 5. Method 17 was found to have a consistent relationship with Method 5 which can be used to correct the measured particulate concentration. The method is presented and discussed in detail in Appendix D.

References

1. Atmospheric Emissions from the Pulp and Paper Manufacturing Industry, EPA-450/1-73-002, September 1973 (also published by NCASI as Technical Bulletin No. 69, February 1974).

2. Preliminary Air Pollution Survey of Odorous Compounds, APTD 69-42, Litton Systems, Inc., October 1969.

3. Preliminary Air Pollution Survey of Hydrogen Sulfide, APTD 69-37, Litton Systems, Inc., October 1969.

4. A Study of the Social and Economic Impact of Odors, Copley International Corporation, EPA Contract No. 68-02-0095, February 1973.

5. Impact of New Source Performance Standards on 1985 National Emissions from Stationary Sources, The Research Corporation of New England, EPA Contract No. 68-02-1382, Task #3, October 24, 1975.

6. Modeling Analysis of the Ambient Air Impact of Kraft Pulp Mills, Walden Research Division of Abcor, Inc., prepared for the Source Receptor Analysis Branch, MDAD, OAQPS, OAWM, EPA, October 1975.

7. Hydrogen Sulfide Health Effects and Recommended Air Quality Standard, Illinois Institute for Environmental Quality, March 1974, distributed by the National Technical Information Service, U.S. Department of Commerce.

8. Air Quality Criteria for Particulate Matter, AP-49, U.S. Department of Health, Education, and Welfare, Washington, D.C., January 1969.

9. Reduction of Total Reduced Sulfur Data from a Kraft Pulp Mill Lime Kiln, Emission Standards and Engineering Division, U.S. EPA, Research Triangle Park, N.C., December 1975.

10. Meeting between EPA and representatives of the kraft pulping industry at Research Triangle Park, N. C. on March 7, 1975.

11. Eddinger, James A., EPA, Trip Report - "Koppers Company at Baltimore, Maryland, and Research Cottrell at Bound Brook, New Jersey," August 25, 1975.

12. Eddinger, James A., EPA, Trip Report - "Wheelabrator Frye at Pittsburgh, Pa.," August 25, 1975.

APPENDIX A

EVOLUTION OF THE PROPOSED STANDARDS

APPENDIX A

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
11/4/70	EPA	Durham, N.C.	Kraft pulp mills were selected as a source category for inclusion in the original Group II standards package.
8/19/71	Alton Box Board Co.	Jacksonville, Fla.	Presurvey of recovery furnace and lime kiln for TRS testing.
8/19/71	Container Corporation of America	Ferdnandina Beach, Fla.	Presurvey of the mill for TRS testing.
8/20/71	International Paper Co.	Panama City, Fla.	Presurvey of the mill for TRS testing.
1/22/72	Western Kraft	Albany, Ga.	Presurvey of the mill for TRS testing.
1/27/72	American Can Co.	Halsey, Oregon	Presurvey of recovery furnace for TRS testing.
2/9/72	International Paper Co.	Ticonderoga, N.Y.	Presurvey of recovery furnace for TRS testing.
2/17/72	Alton Box Board Co.	Jacksonville, Fla.	Presurvey of recovery furnace for TRS testing.
2/24/72	Champion International	Courtland, Ala.	Presurvey of the mill for TRS testing.
3/1/72	Crown Zellerbach	Port Townsend, Wash.	Presurvey of the mill for TRS testing.
3/2/72	Boise Cascade Corp.	Wallula, Wash.	Presurvey of the lime kiln for TRS testing.
4/4/72	Westvaco	Wickliffe, Ky.	Presurvey of incinerator for TRS testing.
4/5/72	Westvaco	Charleston, S.C.	Presurvey of the mill for TRS testing.
4/7/72	Champion International	Pasadena, Texas	Presurvey of recovery furnace for TRS testing.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
4/21/72	Weyerhauser Co.	Vallient, Okla.	Presurvey of the mill for TRS testing.
6/3-9/72	Champion International	Pasadena, Texas	Source tests on the recovery furnace for TRS and particulate emissions, and the black liquor oxidation system for TRS emissions.
7/13/72	National Council of the Paper Industry for Air and Stream Improvement (NCASI), and industry representatives from various companies.	New York City, N.Y.	EPA met with representatives of the kraft pulping industry to discuss the selection of pollutants and affected facilities, and the testing program.
7/13-21/72	American Can Co.	Halsey, Oregon	Source tests on the recovery furnace for TRS and particulate emissions, and on the smelt dissolving tank for TRS and particulate emissions.
7/24/72	Weyerhauser Co.	Everett, Wash.	Presurvey of the smelt dissolving tank for TRS testing.
10/2-7/72	Westvaco	Wickliffe, Ky.	Source test on the incinerator for TRS emissions.
10/18/72	NCASI and industry representatives	New York City, N.Y.	EPA met with industry representatives to discuss the development of the standards.
10/24/72-11/3/72	Champion International	Courtland, Ala.	Source test on the recovery furnace for TRS and particulate emissions.
11/10-19/72	Champion International	Courtland, Ala.	Source test on the recovery furnace for TRS emissions, on the brown stock washers for TRS emissions, and on the black liquor oxidation system for TRS emissions.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
12/11-14/72	Westvaco	Wickliffe, Ky.	Source test on the incinerator unit for TRS emissions.
12/21/72	Industry representatives	Durham, N.C.	EPA met with industry representatives to discuss the draft package of the standards for control of TRS emissions.
1/30/73	EPA	Durham, N.C.	EPA Working Group reviewed the recommended standards.
2/20/73	EPA	Raleigh, N.C.	Review of the recommended standards by the National Air Pollution Control Techniques Advisory Committee (NAPCTAC).
3/5/73	Industry representatives	Durham, N.C.	EPA met with industry representatives to discuss their comments on the recommended TRS standards.
3/27/73	NCASI	Durham, N.C.	EPA met with NCASI to discuss the recommended TRS standards.
4/73	EPA	Durham, N.C.	EPA decided to expand the standards package by including all sources of TRS and the three significant sources of particulate matter at a kraft pulp mill. Further source testing was authorized to obtain data to support the additional standards.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
4/23-25/73	International Paper Co.	Panama City, Fla.	Presurvey of the lime kiln for TRS and particulate testing. Experimental source test on the lime kiln to determine if the particulate dust affects the accuracy of the TRS measurements.
5/3/73	NCASI	Durham, N.C.	EPA met with NCASI to discuss the development plan for control of particulate emissions and for control of additional TRS sources.
6/18/73	Escanaba Paper Co. (Mead Corp.)	Escanaba, Mich.	Presurvey of all facilities for possible TRS and particulate testing.
6/20/73	Fibreboard Kraft Mill	Antioch, Cal.	Presurvey of the mill for TRS and particulate testing.
6/21/73	Louisiana-Pacific Corp.	Samoa, Cal.	Presurvey of the lime kiln for TRS and particulate testing.
6/22/73	Crown Zellerbach Corp.	Wauna, Oregon	Presurvey of the lime kiln for TRS and particulate testing.
6/25/73	St. Regis Paper Co.	Tacoma, Wash.	Presurvey of the mill for TRS and particulate testing.
6/26/73	Weyerhauser Co.	Longview, Wash.	Presurvey of the lime kiln for TRS and particulate testing.
7/11/73	NCASI	Durham, N.C.	EPA met with NCASI to discuss the development of additional TRS and particulate standards.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
9/11/73	Crown Zellerbach Corp.	Camas, Wash.	Presurvey of the smelt dissolving tank for TRS and particulate testing.
9/12/73	Weyerhauser Canada Ltd.	Kamloops, British Columbia, Canada	Presurvey of recovery furnace for TRS and particulate testing.
9/13/73	British Columbia Forests Products Kraft Pulp Mill	MacKenzie, British Columbia, Canada	Presurvey of recovery furnace for TRS and particulate testing.
9/17-27/73	Escanaba Paper Co. (Mead Corp.)	Escanaba, Mich.	Source tests on the lime kiln for TRS emissions, and on the smelt dissolving tank for TRS and particulate emissions.
10/5/73	Boise Cascade Corp.	St. Helens, Oregon	Presurvey of the lime kiln for TRS and particulate testing.
10/8-12/73	Weyerhauser Co.	Everett, Wash.	Source test on the smelt dissolving tank for particulate emissions. Visible emissions data were also recorded.
10/15-20/73	Crown Zellerbach Corp.	Camas, Wash.	Source test on the smelt dissolving tank for particulate emissions. Visible emissions data were also recorded.
10/29/73-11/8/73	Champion International	Courtland, Ala.	Source tests on the lime kiln for TRS emissions, on the recovery furnace for particulate emissions, and on the smelt dissolving tank for TRS and particulate emissions. Visible emissions data were also taken for the smelt dissolving tank.
11/1/73	Brunswick Pulp and Paper Co.	Brunswick Ga.	Presurvey of recovery furnace for particulate testing.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
11/13-16/73	Weyerhauser Co.	Vallient, Okla.	Source test on the lime kiln for particulate emissions.
11/19/73	Brunswick Pulp and Paper Co.	Brunswick, Ga.	Record visible emissions data on the recovery furnace plume.
12/11-13/73	Alton Box Board	Jacksonville, Fla.	Source test on the recovery furnace for particulate emissions.
1/21-25/74	Brunswick Pulp and Paper Co.	Brunswick, Ga.	Source test on the recovery furnace for particulate emissions. Visible emissions data were also recorded.
1/24/74	Gilman Paper Co.	St. Mary's, Ga.	Presurvey of recovery furnace for particulate testing.
1/25/74	Buckeye Cellulose Corp.	Foley, Fla.	Presurvey of recovery furnace for particulate testing.
2/12-19/74	St. Regis Paper Co.	Tacoma, Wash.	Source test on the recovery furnace for particulate emissions.
3/12/74	Mead Corp.	Chillicothe, Ohio	Presurvey of the lime kiln for emissions testing. Obtain information on additional processes.
3/13/74	Great Northern Paper Co.	Cedar Springs, Ga.	Presurvey the lime kiln for TRS and particulate testing.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
4/1-10/74	St. Regis Paper Co.	Tacoma, Wash.	Source test on the lime kiln for TRS emissions.
4/29/74-5/3/74	Buckeye Cellulose Corp.	Foley, Fla.	Source test on the lime kiln for particulate emissions. Visible emissions data were also recorded.
5/7-14/74	Buckeye Cellulose Corp.	Foley, Fla.	Source test on the recovery furnace for particulate emissions. Visible emissions data were also recorded.
7/16/74	Champion International	Pasadena, Texas	Plant visit to obtain design and performance data on the electrostatic precipitator used to control particulate emissions from the lime kiln.
7/26/74	NCASI	Durham, N.C.	EPA met with NCASI to discuss the additional data and the levels of the emission standards.
8/5-12/74	Mead Corp.	Chillicothe, Ohio	Source test on the lime kiln for particulate emissions. Visible emissions data were also recorded.
9/17-19/74	Great Northern Paper Co.	Cedar Springs, Ga.	Source test on the lime kiln for particulate emissions.
1/21/75	EPA	Durham, N.C.	The EPA Working Group reviewed the recommended standards.
2/20/75	EPA	Atlanta, Ga.	Review of the recommended standards by the NAPCTAC.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
3/7/75	NCASI and industry representatives	Research Triangle Park, N.C.	EPA met with NCASI and industry representatives to discuss their comments on the recommended standards.
5/1/75	Babcock and Wilcox	Durham, N.C.	EPA met with representatives of Babcock and Wilcox to discuss problems with burning vent gases in existing recovery furnaces.
5/14/75	St. Regis Paper Co.	Tacoma, Wash.	114 request for ESP maintenance records.
7/16/75	Koppers Co.	Baltimore, Md.	EPA met with Koppers to discuss ESP performance and maintenance requirements.
7/17/75	Research Cottrell	Bound Brook, N.J.	EPA met with Research Cottrell to discuss ESP performance and maintenance requirements.
8/1/75	Wheelabrator-Frye, Inc.	Pittsburgh, Pa.	EPA met with Wheelabrator-Frye to discuss ESP performance and maintenance requirements.
9/ /75	St. Regis Paper Co.	Tacoma, Wash.	Request for long-term opacity data on the recovery furnace plume.
10/7/75	Escanaba Paper Co. (Mead Corp.)	Escanaba, Mich.	EPA met with Mead representatives to discuss the performance of the TRS monitoring system in use at Escanaba, and the effectiveness of caustic scrubbing in the control of TRS from the lime kiln.

APPENDIX A (continued)

EVOLUTION OF THE PROPOSED STANDARDS

Date	Company, Consultant or Agency	Location	Nature of Action
11/5/75	Teller Environmental Systems, Inc. (TESI)	Worchester, Mass.	EPA met with TESI to discuss application of a cross flow scrubber for control of TRS and particulate emissions from kraft recovery furnaces.
11/12/75	Escanaba Paper Co. (Mead Corp.)	Escanaba, Mich.	EPA obtained one month of TRS data from the continuous monitor on the lime kiln at Escanaba.
3/8/76	EPA	Durham, N.C.	The EPA Working Group reviewed the proposed standards.
4/23/76	EPA	Washington, D.C.	The EPA Steering Committee reviewed the proposed standards.
8/5/76	EPA	Washington, D. C.	The proposed standards package completed external review by Federal Agencies and departments.
8/17/76	EPA	Washington, D. C.	The package was forwarded to Washington for final concurrance.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system, cross-indexed with the October 21, 1974, FEDERAL REGISTER (39 FR 37419) containing the Agency guidelines concerning the preparation of Environmental Impact Statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the FEDERAL REGISTER guidelines.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency Guideline for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
1. Background and description of the proposed action.	
-Describe the recommended or proposed action and its purpose.	The proposed standards are summarized in chapter 1, section 1.1. The statutory basis for the proposed standards (section 111 of the Clean Air Act, as amended) is discussed in the Introduction. The purpose of the proposed standards is discussed in chapter 9, sections 9.1 and 9.2.
-The relationship to other actions and proposals significantly affected by the proposed action shall be discussed, including not only other Agency activities but also those of other governmental and private organizations.	Water effluent limitations for sources in the pulp and paper industry are discussed in chapter 7, section 7.2. Discussion of the economic impacts that the proposed new source performance standards may have on these effluent guidelines is presented in chapter 8.
2. Alternatives to the proposed action.	
-Describe and objectively weigh reasonable alternatives to the proposed action, to the extent such alternatives are permitted by the law. . . For use as a reference point to which other actions can be compared, the analysis of alternatives should include the alternative of taking no action, or of postponing action. In addition, the analysis should include alternatives having different environmental impacts, including proposing standards, criteria, procedures, or actions of varying degrees of stringency. When appropriate, actions with similar environmental impacts but based on different technical approaches should be discussed. This analysis shall evaluate alternatives in such a manner that reviewers can judge their relative desirability.	The alternative control systems, based upon the best combinations of control techniques, are presented in chapter 4, section 4.3. A discussion of the alternative of taking no action and that of postponing the proposed action is presented in chapter 7, sections 7.6.2 and 7.6.3. The alternative systems are discussed throughout the document in the evaluation of the environmental and economic impacts associated with the proposed standards. The selection of the best system for emission reduction, considering costs, is presented in chapter 9, section 9.3. The alternative formats for the proposed standards are discussed and the rationale for the selection of the proposed formats are discussed in chapter 9, section 9.4.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guideline for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
	The emission limits for particulate matter and TRS and the rationale for their selection are discussed in chapter 9, section 9.5. The alternatives considered in the selection of a visible emissions standard for the recovery furnace is presented in chapter 9, section 9.6.
-The analysis should be sufficiently detailed to reveal the Agency's comparative evaluation of the beneficial and adverse environmental, health, social, and economic effects of the proposed action and each reasonable alternative.	A summary of the environmental and economic impacts associated with the proposed standards are presented in chapter 1, section 1.2. A detailed discussion of the environmental effects of each of the alternative control systems can be found in chapter 7. This chapter includes a discussion on the beneficial and adverse impacts on air, water, solid waste, energy, noise, radiation, and other environmental considerations. A detailed analysis of the costs and economic impacts associated with the proposed standards can be found in chapter 8.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT
ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guideline for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
-Where the authorizing legislation limits the Agency from taking certain factors into account in its decision making, the comparative evaluation should discuss all relevant factors, but clearly identify those factors which the authorizing legislation requires to be the basis of the decision making.	The factors which the authorizing legislation requires to be the basis of the decision making are discussed in the Introduction.
-In addition, the reasons why the proposed action is believed by the Agency to be the best course of action shall be explained.	The rationale for the selection of TRS and particulate matter from kraft pulp mills for control under the proposed standards is discussed in chapter 9, section 9.1. The Administrator's decision to control TRS emissions under Federal standards and the reasons for regulating TRS under section 111 of the Clean Air Act is discussed in the Introduction.
3. Environmental impact of the proposed action.	
A. Primary impact Primary impacts are those that can be attributed directly to the action, such as reduced levels of specific pollutants brought about by a new standard and the physical changes that occur in the various media with this reduction.	The primary impacts on mass emissions and ambient air quality due to the alternative control systems is discussed in chapter 7, section 7.1.1. These impacts are summarized in Table 1-2, Matrix of Environmental and Economic Impacts of the Alternative Standards, chapter 1, section 1.2.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guideline for Preparing Regulatory Action Environmental Impact Statements (39 FR 34719)	Location Within the Standards Support and Environmental Impact Statement
B. Secondary impact Secondary impacts are indirect or induced impacts. For example, mandatory reduction of specific pollutants brought about by a new standard could result in the adoption of control technology that exacerbates another pollution problem and would be a secondary impact.	The secondary environmental impacts attributable to the alternative control systems are discussed in chapter 7. These impacts are summarized in Table 7-1, Secondary Environmental Impacts of Individual Control Techniques, chapter 7, introduction. Secondary impacts on air quality are discussed in chapter 7, section 7.1.2. The anticipated impacts on energy requirements due to each alternative control system is discussed in chapter 7, section 7.5.
4. Other considerations.	
A. Adverse impacts which cannot be avoided should the proposal be implemented. Describe the kinds and magnitudes of adverse impacts which cannot be reduced in severity to an acceptable level or which can be reduced to an acceptable level but not eliminated. These may include air or water pollution, damage to ecological systems, reduction in economic activities, threats to health, or undesirable land use patterns. Remedial, protective, and mitigative measures which will be taken as part of the proposed action shall be identified.	A summary of the potential adverse environmental and economic impacts associated with the proposed standards and the alternatives that were considered is discussed in chapter 1, section 1.2 and chapter 7.

CROSS INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (continued)

Agency Guideline for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419)	Location Within the Standards Support and Environmental Impact Statement
B. Relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. Describe the extent to which the proposed action involves trade-offs between short-term environmental gains at the expense of long-term losses or vice versa and the extent to which the proposed action forecloses future options. Special attention shall be given to effects which pose long-term risks to health or safety. In addition, the timing of the proposed action shall be explained and justified.	The discussion of the use of man's environment is included in chapter 7, section 7.6.1. A discussion of the effects of TRS and particulate emissions from kraft pulp mills is included in chapter 9, section 9.1.
C. Irreversible and irretrievalbe commitments of resources which would be involved in the proposed action should it be implemented. Describe the extent to which the proposed action curtails the diversity and range of beneficial uses of the environment. For example, irreversible damage can result if a standard is not sufficiently stringent.	Irreversible and irretrievable commitments of resources are discussed in chapter 7, section 7.6.1.

APPENDIX C

EMISSION SOURCE TEST DATA SUMMARY

INTRODUCTION

This section presents the summaries of the source tests and visible emission measurements cited in Chapter V. Tests were conducted by EPA at 12 mills and include 9 tests for TRS, 13 tests for particulate, and 3 tests for visible emissions. A total of 6 recovery furnaces, 4 smelt dissolving tanks, 4 lime kilns, and one incinerator were tested by EPA for either particulate, TRS, or both. Emission data obtained from operators or state agencies are also reported for some of the facilities. The facilities are identified by the same coding that is used in Chapter V.

Particulate tests were conducted as specified in Method 5, promulgated in the Federal Register on December 23, 1971 (36 FR 24877). Tests for TRS were conducted using EPA Method 16, "Semicontinuous Determination of Sulfur Emissions from Stationary Sources," which will be proposed in the Federal Register at the same time as the kraft mill standards. Visible emission data were gathered by EPA Method 9, originally promulgated in the Federal Register on December 23, 1971 (36 FR 24877) and revised on November 12, 1974 (39 FR 39872).

A description of the facilities tested during the study are presented below. The data presented in this appendix for a facility is referred to by the appropriate letter.

PARTICULATE EMISSION DATA

Recovery Furnaces:

D. Conventional type recovery furnace designed for equivalent pulp production of 602 tons per day. Furnace was operating between 90 and 95 percent of designed capacity during the test period. Particulate emissions are controlled by a wet-bottom electrostatic precipitator which has an operating collection efficiency of 99.5 percent.

J. Low-odor type recovery furnace designed for an equivalent pulp production of 1100 tons per day. Furnace was operating at design capacity during the test period. Particulate emissions are controlled by a dry-bottom electrostatic precipitator which has a design collection efficiency of 99.8. Tests J1 were performed by EPA. Data J2 were obtained from the operator.

K. Low-odor type recovery furnace designed for an equivalent pulp production rate of 863 tons per day. The furnace was operating at 74 percent of design capacity during EPA test period. Particulate emissions are controlled by a dry bottom electrostatic precipitator which has a design collection efficiency of 99.5 percent. Data K1 were obtained from EPA tests, while data K2 were obtained from the state agency.

L. Conventional type recovery furnace designed for an equivalent pulp production of 550 tons per day. Furnace was operating 16 percent above design capacity during EPA test period. The particulate emissions are controlled by an electrostatic precipitator with a design collection efficiency of 99.5 percent. Data L1 were obtained during EPA tests, while data L2 were obtained from the operator.

Smelt Dissolving Tanks:

D. Particulate emissions are controlled by a wet scrubber. Demister pads are also installed to aid the scrubber. The associated recovery furnace operates at an equivalent pulp production rate of 570 tons per day.

E. Particulate emissions are controlled by a wet scrubber which is basically a wet fan cyclone. The associated recovery furnace operates at an equivalent pulp production rate of 770 tons per day.

F. Particulate emissions are controlled by a packed scrubber tower. The associated recovery furnace operates at an equivalent pulp production rate of 450 tons per day. Data F1 are results of tests performed by EPA, while data F2 were obtained from the state agency.

G. Particulate emissions are controlled by a packed scrubber tower. The associated recovery furnace operates at an equivalent pulp production rate of 300 tons per day. Data G1 are results of tests performed by EPA, while data G2 were obtained from the state agency.

Lime Kilns:

K. Rotary lime kiln operating at an equivalent pulp production rate of 320 tons per day. Particulate emissions are controlled by a venturi scrubber which has an operating pressure drop of 31 to 33 inches of water. The lime kiln was tested by EPA on both No. 6 fuel oil (Data K1) and natural gas (Data K2). Data K3 was obtained from the state agency.

L. Rotary lime kiln operating at an equivalent pulp production rate of 500 tons per day. Particulate emissions are controlled by a venturi scrubber which has an operating pressure drop of 15 to 18 inches of water. The lime kiln was tested by EPA on No. 2 fuel oil (Data L1) and natural gas (Data L2). Data L3 was obtained from the operator.

N. Rotary lime kiln operating at an equivalent pulp production rate of about 840 tons per day. Particulate emissions are controlled by a venturi scrubber with an operating pressure drop of 18 inches of water. The lime kiln was tested by EPA on No. 6 fuel oil (N1) and on natural gas (N2).

TRS EMISSION DATA

Incinerator:

The incinerator handles the noncondensable gases from a continuous digester system and a multiple-effect evaporator system. The continuous digester was producing 670 tons of pulp per day. The incinerator was operating at 1000°F with a retention time for the gases of at least 0.5 seconds. Natural gas is fired in the incinerator.

Recovery Furnaces:

A. Conventional type recovery furnace designed for an equivalent pulp production rate of 657 tons per day. TRS emissions are controlled by using black liquor oxidation and maintaining proper furnace operation. The furnace was operating near its design capacity during the EPA test period. Continuous monitoring data were also obtained from the operator.

B. Low-odor type recovery furnace designed for an equivalent pulp production of 300 tons per day. During the EPA testing, the furnace was operating at a rate of about 345 tons of pulp per day. TRS emissions are controlled by eliminating the direct contact evaporator and maintaining proper furnace operation. Noncondensable gases from the brown stock washer system are burned in this furnace. Continuous monitoring data were also obtained from the state agency.

D. Conventional type recovery furnace designed for an equivalent pulp production rate of 602 tons per day. TRS emissions are controlled by black liquor oxidation and maintaining proper furnace operation.

H. Low-odor type recovery furnace operating at an equivalent pulp production rate of about 200 tons per day. TRS emissions are controlled by maintaining proper furnace operation. Data were obtained from the state agency.

K. Low-odor type recovery furnace designed for an equivalent pulp production rate of about 863 tons per day. TRS emissions are controlled by maintaining proper furnace operation. Data were obtained from state agency.

Smelt Dissolving Tanks

D. A wet fan type scrubber is employed to control the particulate emissions. Weak wash liquor is used as the scrubbing medium. The associated recovery furnace operates at an equivalent pulp production rate of 570 tons per day.

E. A wet fan type scrubber is employed to control the particulate emissions. Fresh water is used as the scrubbing medium. The associated recovery furnace operates at an equivalent pulp production rate of 770 tons per day.

Lime Kilns

D. Rotary lime kiln operating at an equivalent pulp production rate of 570 tons per day. TRS emissions are controlled by maintaining proper kiln combustion and proper lime mud washing. Noncondensable gases from the multiple-effect evaporators are burned in the kiln.

E. Rotary lime kiln operating at an equivalent pulp production rate of about 770 tons per day. TRS emissions are controlled by maintaining proper combustion in the kiln, maintaining proper lime mud washing, and using a caustic solution in the particulate scrubber. Noncondensable gases from the digesters, multiple-effect evaporators, condensate stripper, and miscellaneous storage tanks are burned in the kiln. Continuous monitoring data were also obtained from the operator.

K. Rotary lime kiln operating at an equivalent pulp production rate of about 320 tons per day. TRS emissions are controlled by maintaining proper combustion in the kiln and proper lime mud washing. Noncondensable gases from the digesters, multiple-effect evaporators, and turpentine system are burned in the kiln.

O. Rotary lime kiln not tested by EPA. Continuous monitoring data was obtained from the local agency. TRS emissions are controlled by maintaining process combustion in the kiln.

Table 1 - Particulate and Visible Emission Data for Recovery Furnace D

Summary of Results

Run Number	1	2	3
Date - 1973	11/1	11/1	11/2
Test Time - minutes	128	128	128
Production Rate - TPH	-	-	-
Stack Effluent			
Flow rate - DSCFM (X1000)	85	91	80
Flow rate - DSCF/ton	-	-	-
Temperature - °F	321	310	304
Water vapor - Vol. %	30.3	31.5	33.6
CO_2 - Vol. % dry	8.7	9.9	10.2
O_2 - Vol. % dry	9.8	10.6	10.6
CO - Vol. % dry	0	0	0
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.031	.029	.021
gr/ACF	.014	.013	.010
lb/hr	22.5	22.6	14.7
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.041	.045	.043
gr/ACF	.019	.021	.020
lb/hr	30.2	35.3	29.7
lb/ton of product	-	-	-

TABLE 1 (cont.)

Visible Emissions (Normalized to a 3.0 m stack diameter)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1	0-5	0	0
(11/1/73)	5-10	0	0
	10-15	1	25
	15-20	0	0
	20-25	0	0
	25-30	3	75
2			
(11/1/73)		No readings taken	
3	0-5	1	33.3
(11/2/73)	5-10	1	33.3
	10-15	1	33.3

Table 2 - Particulate and Visible Emission Data for Recovery Furnace J'1

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1974	1/22	1/23	1/23	1/24	1/24	1/25
Test Time - minutes	162	162	162	162	162	162
Production Rate - TPH	45.8	45.7	44.9	45.8	45.4	45.5
Stack Effluent						
Flow rate - DSCFM (X1000)	99	93	91	96	93	98
Flow rate - DSCF/ton						
Temperature - °F	405	445	433	434	430	434
Water vapor - Vol. %	27.2	30.7	28.5	29.7	29.6	28.8
CO_2 - Vol. % dry	12.6	14.7	14.1	13.4	14.0	13.1
O_2 - Vol. % dry	6.8	4.7	5.4	6.0	5.2	6.6
CO - Vol. % dry	0.1	0.1	0	0	0.2	0.2
Particulate Emissions						
Probe and filter catch						
gr/DSCF	.011	.018	.013	.01	.01	.014
gr/ACF	.005	.007	.005	.004	.004	.006
lb/hr	9.4	14.4	9.9	8.2	8.1	11.8
lb/ton of product	.21	.31	.22	.18	.18	.26
Total catch						
gr/DSCF	.017	.03	.027	.02	.021	.025
gr/ACF	.007	.012	.011	.008	.009	.01
lb/hr	14.0	23.6	21.0	16.4	17.1	21.0
lb/ton of product	.31	.52	.47	.36	.38	.46

TABLE 2 (cont.)

Visible Emissions (Normalized to a 3.0 m stack diameter)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1 (1/22/74)	0-5	30	55.5
	5-10	19	35.2
	10-15	5	9.3
2 (1/23/74)	0-5	48	100
	5-10	0	0
3 (1/23/74)	0-5	15	75.0
	5-10	5	25.0
4 (1/24/74)	0-5	47	100
	5-10	0	0
5 (1/24/74)	0-5	34	85.0
	5-10	8	15.0
6 (1/25/74)	0-5	34	97.1
	5-10	1	2.9

Table 3 - Particulate and Visible Emission Data for Recovery Furnace J"1

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1974	1.22	1.23	1.23	1.24	1.24	1.25
Test Time - minutes	162	162	162	162	162	162
Production Rate - TPH	45.8	45.7	44.9	45.8	45.4	45.3
Stack Effluent						
Flow rate - DSCFM (X1000)	112	106	108	107	108	109
Flow rate - DSCF/ton	147	139	144	140	143	144
Temperature - °F	449	403	401	408	400	393
Water vapor - Vol. %	27.9	27.8	29.5	29.0	29.7	29.1
CO_2 - Vol. % dry	14.9	14.7	11.4	13.2	14.0	13.2
O_2 - Vol. % dry	4.7	4.7	8.5	6.1	5.2	6.2
CO - Vol. % dry	0	0.1	0	0	0.2	0
Particulate Emissions						
Probe and filter catch						
gr/DSCF	.058	.055	.052	.057	.051	.052
gr/ACF	.024	.024	.022	.024	.022	.023
lb/hr	56.0	50.5	48.4	51.9	47.0	48.6
lb/ton of product	1.2	1.1	1.1	1.1	1.0	1.1
Total catch						
gr/DSCF	.067	.063	.062	.064	.061	.065
gr/ACF	.028	.028	.027	.028	.026	.028
lb/hr	64.7	57.5	57.5	59.0	56.8	61.0
lb/ton of product	1.4	1.3	1.3	1.3	1.3	1.4

TABLE 3 (cont.)

Visible Emissions (Normalized to a 3.0 m stack diameter)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1 (1/22/74)	0-10	0	0
	10-20	5	9.3
	20-30	22	40.7
	30-40	27	50.0
	40-50	0	0
2 (1/23/74)	0-10	0	0
	10-20	1	2.1
	20-30	2	4.2
	30-40	23	47.9
	40-50	22	45.8
3 (1/23/74)	0-10	0	0
	10-20	11	30.6
	20-30	12	33.3
	30-40	12	33.3
	40-50	1	2.8
4 (1/24/74)	0-10	0	0
	10-20	1	2.9
	20-30	6	17.1
	30-40	18	51.4
	40-50	10	28.6
5 (1/24/74	0-10	0	0
	10-20	0	0
	20-30	5	15.2
	30-40	24	72.7
	40-50	4	12.1
6 (1/25/74)	0-10	0	0
	10-20	0	0
	20-30	5	13.2
	30-40	14	36.8
	40-50	17	44.7
	50-60	2	5.3

Table 4 - Particulate Emission Data for Recovery Furnace K1

Summary of Results

Run Number	1	2	3	4	5
Date - 1974	2/2	2/13	2/14	2/15	2/18
Test Time - minutes	224	224	448	162	336
Production Rate - TPH	-	-	-	-	-
Stack Effluent					
Flow rate - DSCFM (X1000)	141,928	148,427	159,325	160,461	148,142
Flow rate - DSCF/ton	-	-	-	-	-
Temperature - °F	338	349	361	347	345
Water vapor - Vol. %	21.5	22.8	23.1	22.1	22.9
CO_2 - Vol. % dry	8.9	9.7	9.6	8.9	8.5
O_2 - Vol. % dry	9.9	9.8	9.7	10.0	10.5
CO - Vol. % dry	0	0	0	0	0
Particulate Emissions					
Probe and filter catch					
gr/DSCF	.003	.003	.002	.002	.003
gr/ACF	.001	.002	.001	.001	.001
lb/hr	3.2	4.0	3.4	3.0	3.5
lb/ton of product	-	-	-	-	-
Total catch					
gr/DSCF	.008	.011	.005	.009	.011
gr/ACF	.004	.006	.002	.005	.006
lb/hr	9.8	13.7	6.2	12.0	14.5
lb/ton of product	-	-	-	-	-

Table 5 - Particulate and Visible Emission Data for Recovery Furnace L1

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1974	3.7	5/8	5/9	5/10	5/13	5/14
Test Time - minutes	288	240	240	240	240	240
Production Rate - TPH						
Stack Effluent						
Flow rate - DSCFM (X1000)	112	118	113	114	120	115
Flow rate - DSCF/ton						
Temperature - °F	301	293	307	304	291	276
Water vapor - Vol. %	31.9	29.6	32.6	32.3	32.1	32.4
CO_2 - Vol. % dry	13.5	11.3	9.5	8.7	9.1	9.0
O_2 - Vol. % dry	5.4	6.9	8.2	8.9	8.2	6.2
CO - Vol. % dry	1.4	1.4	2.3	1.9	2.2	3.8
Particulate Emissions						
Probe and filter catch						
gr/DSCF	.014	.012	.012	.016	.015	.014
gr/ACF	.007	.006	.006	.006	.008	.007
lb/hr	13.9	12.2	12.8	11.7	15.5	15.8
lb/ton of product						
Total catch						
gr/DSCF	.046	.048	.044	.034	.063	.056
gr/ACF	.022	.024	.021	.016	.03	.05
lb/hr	45	49	43	33	62	105
lb/ton of product						

TABLE 5 (cont.)

Visible Emissions (Normalized to a 3.0 m stack diameter)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
R-7	0-5	31	41.3
(5/7/74)	5-10	44	58.7
R-8	0-5	46	61.3
(5/8/74)	5-10	28	38.7
R-9	0-5	30	63.8
(5/9/74)	5-10	17	36.2
R-10	0-5	42	61.2
(5/10/74)	5-10	26	38.8
R-11	0-5	46	63.0
(5/13/74)	5-10	25	37.0
R-12	0-5	45	52.3
(5/14/74)	5-10	41	47.7

Table 6

ADDITIONAL PARTICULATE EMISSION DATA FOR RECOVERY FURNACES

	Date	Concentration gr/dscf	Emission Rate lb/hr	Emission Rate lb/ton
Recovery Furnace J^{1}2[a]				
Test 1	12/19/72	.0163	14.9	-
Test 2	7/23/73	.0179	14.3	-
Average		.0171	14.6	-
Recovery Furnace J^{11}2[a]				
Test 1	12/19/72	.060	46.5	-
Test 2	7/23/75	.0385	28.7	-
Average		.049	37.6	-
Recovery Furnace K2[b]				
Low	9/7/73	.001	1.2	0.05
High	3/18/75	.05	64.4	3.0
Average		.017	22.3	0.86
Recovery Furnace L2[c]				
Low	4/30/73	.005	4.5	-
High	2/21/73	.023	28.5	-
Average		.01	11.3	-

[a] Tested by operator using in-stack filter.

[b] Tested by operator using Washington State sampling train (in-stack filter plus impingers)

[c] Tested by operator using total EPA sampling train.

Table 7 - Particulate and Visible Emission Data for Smelt Dissolving Tank D

Summary of Results

Run Number	1	2	3
Date - 1973	11/1	11/2	11/2
Test Time - minutes	144	144	144
Production Rate - TPH	25.9	25.6	25.6
Stack Effluent			
Flow rate - DSCFM (X1000)	8880	9339	10787
Flow rate - DSCF/ton	20,571	21,888	25,282
Temperature - °F	172	172	170
Water vapor - Vol. %	41.2	41.0	33.2
CO_2 - Vol. % dry	0.1	0.1	0.1
O_2 - Vol. % dry	19.4	20.4	20.7
CO - Vol. % dry	0	0	0
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.058	.051	.027
gr/ACF	.028	.025	.015
lb/hr	4.4	4.1	2.5
lb/ton of product	0.17	0.16	0.098
Total catch			
gr/DSCF	.09	.067	.037
gr/ACF	.044	.032	.02
lb/hr	6.9	5.3	3.3
lb/ton of product	0.266	0.207	0.129

Table 7 - Particulate and Visible Emission Data for Smelt Dissolving Tank D (continued)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1	0-5	6	100
	5-10	0	0
2	0-5	6	100
	5-10	0	0

Table 8 - Particulate Emission Data for Smelt Dissolving Tank E

Summary of Results

Run Number	1	2	3
Date - 1973	9/18	9/19	9/19
Test Time - minutes	120	120	120
Production Rate - TPH	30.1	34.1	34.1
Stack Effluent			
Flow rate - DSCFM (X1000)	19,542	18,760	18,720
Flow rate - DSCF/ton	38,954	33,009	32,938
Temperature - °F	150	151	153
Water vapor - Vol. %	23.8	25.8	26.5
CO_2 - Vol. % dry	0.3	0.2	0.2
O_2 - Vol. % dry	21.8	21.3	21.3
CO - Vol. % dry	0.2	0.1	0.1
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.024	.026	.023
gr/ACF	.015	.016	.014
lb/hr	4.0	4.1	3.6
lb/ton of product	0.133	0.12	0.106
Total catch			
gr/DSCF	.037	.036	.035
gr/ACF	.024	.023	.021
lb/hr	6.2	5.8	5.6
lb/ton of product	0.206	0.17	0.164

Table 9 - Particulate and Visible Emission Data for Smelt Dissolving Tank F1

Summary of Results

Run Number	1	2	3
Date - 1973	10/11	10/12	10/12
Test Time - minutes	220	220	220
Production Rate - TPH	17.5	18.8	19.1
Stack Effluent			
Flow rate - DSCFM (X1000)	3710	3600	3420
Flow rate - DSCF/ton	12,720	11,489	10,743
Temperature - °F	174	180	177
Water vapor - Vol. %	44.8	47.4	47.8
CO_2 - Vol. % dry	0.0	0.2	0.2
O_2 - Vol. % dry	20.6	19.8	19.8
CO - Vol. % dry	-	-	-
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.114	.141	.129
gr/ACF	.053	.062	.056
lb/hr	3.6	4.4	3.8
lb/ton of product	.206	.231	.198
Total catch			
gr/DSCF	.121	.149	.136
gr/ACF	.056	.065	.059
lb/hr	3.8	4.6	4.0
lb/ton of product	.218	.244	.208

Table 9 - Particulate and Visible Emission Data for Smelt Dissolving Tank F1 (continued)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1	0-5	9	100
	5-10	0	0

Table 10 - Particulate and Visible Emission Data for Smelt Dissolving Tank G1

Summary of Results

Run Number	1	2	3	4
Date - 1973	10/16	10/18	10/19	10/20
Test Time - minutes	180	180	180	180
Production Rate - TPH	12.3	10.5	10.4	12.4
Stack Effluent				
Flow rate - DSCFM (X1000)	5170	5280	5470	4840
Flow rate - DSCF/ton	25,220	30,171	31,558	23,419
Temperature - °F	160	168	167	165
Water vapor - Vol. %	35.1	35.1	37.7	34.2
CO_2 - Vol. % dry	0	0	0	0
O_2 - Vol. % dry	20.6	20.7	21.0	20.8
CO - Vol. % dry	-	-	-	-
Particulate Emissions				
Probe and filter catch				
gr/DSCF	.043	.066	.094	.061
gr/ACF	.024	.037	.05	.034
lb/hr	1.9	3.0	4.4	2.5
lb/ton of product	.155	.286	.422	.205
Total catch				
gr/DSCF	.049	.071	.096	.069
gr/ACF	.028	.04	.051	.037
lb/hr	2.2	3.2	4.5	2.8
lb/ton of product	.177	.308	.433	.223

Table 10 - Particulate and Visible Emission Data for Smelt Dissolving Tank G1 (continued)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1	0-5	2	100
2	0-5	10	100

Table 11

ADDITIONAL PARTICULATE EMISSION DATA FOR SMELT DISSOLVING TANKS*

	Date	Concentration gr/dscf	Emission Rate lb/hr	Emission Rate lb/ton
Smelt Dissolving Tank F2				
Low	8/12/73	-	-	0.08
High	9/17/73	-	-	0.48
Average				0.19
Smelt Dissolving Tank G2				
Low	9/11/73	0.037	-	0.13
High	1/11/73	0.075	-	0.4
Average		0.056	-	0.21

*Tested by operators using Washington State sampling train (in-stack filter and impingers)

Table 12 - Particulate Emission Data for Lime Kiln K1

Summary of Results

Run Number	1	2	3
Date - 1974	2/12	2/13	2/14
Test Time - minutes	120	120	120
Production Rate - TPH	0.1	0.1	0.1
Stack Effluent			
Flow rate - DSCFM (X1000)	14,755	14,292	13,165
Flow rate - DSCF/ton	-	-	-
Temperature - °F	151	151	151
Water vapor - Vol. %	25.2	24.3	25.5
CO_2 - Vol. % dry	9.8	11.5	11.5
O_2 - Vol. % dry	11.5	10.5	10.9
CO - Vol. % dry	0	0	0
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.108	.097	.102
gr/ACF	.07	.064	.066
lb/hr	13.7	11.9	11.6
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.113	.105	.116
gr/ACF	.073	.069	.076
lb/hr	14.3	12.8	13.1
lb/ton of product	-	-	-

Table 13 - Particulate Emission Data for Lime Kiln K2

Summary of Results		
Run Number	1	2
Date - 1974	2/14	2/14
Test Time - minutes	120	120
Fuel	Gas	Gas
Stack Effluent		
Flow rate - DSCFM (X1000)	13,896	11,560
Flow rate - DSCF/ton	-	-
Temperature - °F	156	152
Water vapor - Vol. %	27.0	24.5
CO_2 - Vol. % dry	9.8	9.7
O_2 - Vol. % dry	10.9	10.9
CO - Vol. % dry	0.1	0
Particulate Emissions		
Probe and filter catch		
gr/DSCF	.06	.037
gr/ACF	.038	.024
lb/hr	7.1	3.7
lb/ton of product	-	-
Total catch		
gr/DSCF	.089	.064
gr/ACF	.056	.042
lb/hr	10.6	6.4
lb/ton of product	-	-

Table 14 - Particulate and Visible Emission Data for Lime Kiln L1

Summary of Results

Run Number	1	2	3
Date - 1974	5/2	5/2	5/3.
Test Time - minutes	144	144	144
Fuel	Oil	Oil	Oil
Stack Effluent			
Flow rate - DSCFM (X1000)	14,663	15,214	14,984
Flow rate - DSCF/ton	-	-	-
Temperature - °F	171	168	169
Water vapor - Vol. %	41.0	38.5	39.0
CO_2 - Vol. % dry	20.7	20.7	21.6
O_2 - Vol. % dry	3.2	3.2	3.0
CO - Vol. % dry	.3	.3	.9
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.25	.261	.233
gr/ACF	.128	.137	.121
lb/hr	32.0	34.1	29.9
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.259	.274	.237
gr/ACF	.13	.143	.123
lb/hr	32.5	35.7	30.5
lb/ton of product	-	-	-

Table 14 - Particulate and Visible Emission Data for Lime Kiln L1 (continued)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
1A	0-5	0	0
	5-10	21	100
1B	0-5	0	0
	5-10	23	100
2A	0-5	0	0
	5-10	20	100
2B	0-5	—— STEAM INTERFERENCE ——	
	5-10		
3A	0-5	0	0
	5-10	16	100
3B	0-5	—— STEAM INTERFERENCE ——	
	5-10		

Table 15 - Particulate and Visible Emission Data for Lime Kiln L2

Summary of Results

Run Number	1	2	3
Date - 1974	4/30	5/1	5/1
Test Time - minutes	144	144	144
Fuel	Gas	Gas	Gas
Stack Effluent			
Flow rate - DSCFM (X1000)	15,170	15,761	14,453
Flow rate - DSCF/ton	-	-	-
Temperature - °F	170	163	171
Water vapor - Vol. %	41.0	34.5	41.0
CO_2 - Vol. % dry	17.1	16.8	18.0
O_2 - Vol. % dry	3.4	1.9	2.8
CO - Vol. % dry	0	0.1	0
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.033	.026	.021
gr/ACF	.016	.014	.011
lb/hr	4.3	3.5	2.7
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.037	.031	.028
gr/ACF	.019	.017	.014
lb/hr	4.8	4.2	3.4
lb/ton of product	-	-	-

Table 15 - Particulate and Visible Emission Data for Lime Kiln L2 (continued)

Test	Opacity (%)	Number of 6-Minute Averages in Range	% of Total
4A	0-5	0	0
	5-10	13	100
4B	0-5	—— STEAM INTERFERENCE ——	
	5-10		
5A	0-5	0	0
	5-10	7	33
	10-15	14	67
5B	0-5	—— STEAM INTERFERENCE ——	
	5-10		
6A	0-5	0	0
	5-10	0	0
	10-15	22	100
6B	0-5	—— STEAM INTERFERENCE ——	
	5-10		

Table 16 - Particulate Emission Data for Lime Kiln N1

Summary of Results

Run Number	1	2	3
Date - 1974	9/19	9/19	9/20
Test Time - minutes	120	120	120
Fuel	Oil	Oil	Oil
Stack Effluent			
Flow rate - DSCFM (X1000)	21,159	25,575	33,475
Flow rate - DSCF/ton	-	-	-
Temperature - °F	148	152	149
Water vapor - Vol. %	36.5	32.6	36.3
CO_2 - Vol. % dry	13.8	14.8	19.3
O_2 - Vol. % dry	7.4	7.3	4.7
CO - Vol. % dry	0.1	0.4	0.5
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.031	.092	.095
gr/ACF	.02	.057	.06
lb/hr	5.6	20.1	27.1
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.06	.107	.123
gr/ACF	.039	.067	.08
lb/hr	10.9	23.5	36.0
lb/ton of product	-	-	-

Table 17 - Particulate Emission Data for Lime Kiln N2

Summary of Results

Run Number	1	2	3
Date - 1974	9/17	9/18	9/18
Test Time - minutes	120	120	120
Fuel	Gas	Gas	Gas
Stack Effluent			
Flow rate - DSCFM (X1000)	24,054	22,342	24,964
Flow rate - DSCF/ton	-	-	-
Temperature - °F	155	151	154
Water vapor - Vol. %	41.2	41.0	39.0
CO_2 - Vol. % dry	16.9	10.4	15.9
O_2 - Vol. % dry	4.8	7.8	5.7
CO - Vol. % dry	0.7	0.7	0.3
Particulate Emissions			
Probe and filter catch			
gr/DSCF	.107	.034	.048
gr/ACF	.063	.021	.029
lb/hr	22.6	6.6	10.3
lb/ton of product	-	-	-
Total catch			
gr/DSCF	.156	.113	.086
gr/ACF	.092	.069	.052
lb/hr	32.2	21.5	18.3
lb/ton of product	-	-	-

Table 18

ADDITIONAL PARTICULATE EMISSION DATA FOR LIME KILNS

	Date	Concentration gr/dscf	Emission Rate lb/hr	lb/ton
Lime Kiln K3*				
Low	10/29/73	.014	1.0	0.1
High	2/26/73	.073	5.3	.62
Average		.045	3.5	.26
Lime Kiln L3**				
Low	11/8/73	.017	2.4	-
High	11/8/73	.066	9.2	-
Average		.041	5.2	-

*Tested by operators using Washington State sampling train (in-stack filter and impingers).

**Tested by operator using total EPA sampling train.

Table 19 - TRS Emissions from Separate Incinerator

Summary of Results

Run Number	1	2	3	4
Date - 1972	10/5	10/6	10/7	12/13
Test Time - minutes	240	240	240	240
Production Rate - TPH	-	-	-	-
Stack Effluent				
Flow rate - DSCFM (X1000)	2610	2223	2302	-
Flow rate - DSCF/ton	-	-	-	-
Temperature - °F	805	805	805	-
Water vapor - Vol. %	6.3	4.3	5.4	-
CO_2 - Vol. % dry	2.6	2.4	2.1	9.0
O_2 - Vol. % dry	11.8	12.0	12.7	15.7
CO - ppm	0	0	0	0
TRS Emissions				
ppm	2.8	0.4	1.6	0.9
lb/hr	1.5	0.2	0.6	0.4
lb/ton of pulp	0.06	0.007	0.02	0.02
SO_2 Emissions				
ppm	25	306	1050	-
lb/hr	9.4	96.9	358	-
lb/ton of pulp	0.4	3.8	13.9	-

Table 20 - TRS Emissions from Recovery Furnace A

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1972	6/3	6/4	6/5	6/6	6/7	6/8
Test Time - minutes	240	240	240	240	240	240
Production Rate - TPH	-	-	-	-	-	-
Stack Effluent						
Flow rate - DSCFM (X1000)	142	-	145	148	-	-
Flow rate - DSCF/ton	-	-	-	-	-	-
Temperature - °F	314	-	304	303	-	-
Water vapor - Vol. %	25.5	-	25.3	21.9	-	-
CO_2 - Vol. % dry	10.4	8.2	10.7	11.8	12.9	11.1
O_2 - Vol. % dry	10.7	11.4	11.4	10.1	10.1	9.9
CO - ppm	153	93	84	95	102	51
TRS Emissions						
ppm	2.0	1.4	1.4	1.5	0.7	1.6
lb/hr	1.5	1.1	1.1	1.2	0.6	1.2
lb/ton of pulp	-	-	-	-	-	-
SO_2 Emissions						
ppm	45	116	79	118	50	119
lb/hr	85.0	-	-	-	-	-
lb/ton of pulp	-	-	-	-	-	-

Table 21 - TRS Emissions from Recovery Furnace B

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1972	7/13	7/14	7/15	7/18	7/19	7/20
Test Time - minutes	240	240	240	240	240	240
Production Rate - TPH	-	-	-	-	-	-
Stack Effluent						
Flow rate - DSCFM (X1000)	85	84	86	-	-	-
Flow rate - DSCF/ton	-	-	-	-	-	-
Temperature - °F	395	400	415	-	-	-
Water vapor - Vol. %	-	-	-	-	-	-
CO_2 - Vol. % dry	-	12.3	12.4	12.7	12.0	12.4
O_2 - Vol. % dry		8.1	7.6	7.7	8.0	8.0
CO - ppm	0	0	0	0	0	0
TRS Emissions						
ppm	1.6	0.2	0.5	0.3	0.4	0.3
lb/hr		0.7	0.1	0.2	0.2	0.2
lb/ton of pulp*	.05	.01	.02	.01	.01	.01
SO_2 Emissions						
ppm	0.9	-	-	-	-	-
lb/hr	-	-	-	-	-	-
lb/ton of pulp	-	-	-	-	-	-

* Based on 334.5 ATDP/day

Table 22 - TRS Emissions from Recovery Furnace D

Summary of Results

Run Number	1	2	3	4	5
Date - 1972	11/11	11/12	11/13	11/14	11/15
Test Time - minutes	240	240	240	240	240
Production Rate - TPH	-	-	-	-	-
Stack Effluent					
Flow rate - DSCFM (X1000)	73.2	73.2	73.2	73.2	73.2
Flow rate - DSCF/ton					
Temperature - °F					
Water vapor - Vol. %	35	35	35	35	35
CO_2 - Vol. % dry					
O_2 - Vol. % dry					
CO - ppm					
TRS Emissions					
ppm	3.1	2.8	3.9	7.0	2.8
lb/hr	55.1	48.9	53.7	12.5	46.0
lb/ton of pulp	-	-	-	-	-
SO_2 Emissions					
ppm	15.5	1.0	22.9	5.0	14.2
lb/hr	162	10	239	52	149
lb/ton of pulp	-	-	-	-	-

Table 23

ADDITIONAL TRS EMISSION DATA FOR RECOVERY FURNACES*

	Recovery Furnace A TRS Concentration (ppm, daily average basis)			Recovery Furnace B TRS Concentration (ppm, daily average basis)	
Month	Maximum	Average	Month	Maximum	Average
July 1971	6.0	3.1	April 1972	1.4	0.7
Aug.	20.0	2.4	May	2.3	1.2
Sept.	5.0	1.5	June	2.8	1.5
Oct.	10.9	2.8	July	4.6	1.1
Nov.	4.4	1.3	Aug.	5.0	1.5
Dec.	9.8	1.8	Oct.	1.9	0.7
Jan. 1972	5.5	1.6	Nov.	0.7	0.4
Feb.	3.3	1.3	Dec.	1.0	0.7
March	2.5	1.0	Jan. 1973	1.5	0.8
April	5.3	2.0	Feb.	2.6	1.0
May	5.5	2.1	March	2.4	0.9
June	8.2	3.8	April	1.5	0.8
July	9.8	3.7	May	1.6	1.0
Aug.	9.0	3.3	June	1.9	1.1
Sept.	4.9	2.9	July	1.6	1.0
Oct.	6.1	2.2	Aug.	3.1	1.2
			Sept.	1.8	0.8
			Oct.	2.0	0.9
			Nov.	1.6	0.8
			Dec.	3.4	1.6

*Tested by operators using barton titrators.

Table 23 (cont.)

ADDITIONAL TRS EMISSION DATA FOR RECOVERY FURNACES

	Recovery Furnace A TRS Concentration (ppm, daily average basis)			Recovery Furnace B TRS Concentration (ppm, daily average basis)	
Month	Maximum	Average	Month	Maximum	Average
			Jan. 1974	1.4	0.8
			Feb.	1.9	1.3
			March	5.0	1.6
			April	2.4	1.2
			May	1.8	1.0
			June	1.5	1.0

	Recovery Furnace H TRS Concentration (ppm, daily average basis)			Recovery Furnace K TRS Concentration (ppm, daily average basis)	
Month	Maximum	Average	Month	Maximum	Average
April 1972	3	2.1	Aug. 1973	6.2	1.0
May	4	2.1	Sept.	32.0	5.2
June	7	3.5	Oct.	7.3	2.4
June 1972	8	3.1	Nov.	17.0	4.1
July	4	2.4	Dec.	1.2	0.7
Aug.	4	1.9	Jan. 1974	1.8	0.6
Sept.	2	1.3	Feb.	2.4	1.0
Oct.	6	1.8	March	9.7	2.3
			April	3.0	1.4
			May	3.4	1.4

Table 24 - TRS Emissions from Smelt Dissolving Tank D

Summary of Results

Run Number	1	2	3
Date - 1973	10/31	11/1	11/2
Test Time - minutes	240	240	240
Production Rate - TPH	25.1	25.9	25.6
Stack Effluent			
Flow rate - DSCFM	9000	8880	9400
Flow rate - DSCF/ton	21514	20571	22031
Temperature - °F			
Water vapor - Vol. %	37	41	40
CO_2 - Vol. % dry			
O_2 - Vol. % dry			
CO - ppm			
TRS Emissions			
ppm	8.1	8.8	6.9
lb/hr	0.43	0.44	0.38
lb/ton of pulp	0.017	0.017	.015

Table 25 - TRS Emissions from Smelt Dissolving Tank E

Summary of Results

Run Number	1	2	3
Date - 1973	9/18	9/19	9/20
Test Time - minutes	240	240	240
Production Rate - TPH	30.1	34.1	31.3
Stack Effluent			
Flow rate - DSCFM	19542	18740	19100
Flow rate - DSCF/ton	38954	32974	36613
Temperature - °F			
Water vapor - Vol. %	26	26	23.3
CO_2 - Vol. % dry			
O_2 - Vol. % dry			
CO - ppm			
TRS Emissions			
ppm	2.4	1.9	2.7
lb/hr	0.27	0.20	0.28
lb/ton of pulp	0.009	.006	.009

Table 26 - TRS Emissions from Lime Kiln D

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1973	11/5	11/7	11/7	11/7	11/8	11/8
Test Time - minutes	240	240	240	240	240	240
Production Rate - TPH						
Stack Effluent						
Flow rate - DSCFM (X1000)						
Flow rate - DSCF/ton						
Temperature - °F						
Water vapor - Vol. %	43	35	40	38	41	31
CO_2 - Vol. % dry						
O_2 - Vol. % dry						
CO - ppm						
TRS Emissions						
ppm	3.5	24.1	2.8	5.7	4.6	17.8
lb/hr						
lb/ton of pulp						

Table 27 - TRS Emissions from Lime Kiln E

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1973	9/24	9/25	9/26	9/26	9/27	9/27
Test Time - minutes	240	240	240	240	240	240
Production Rate - TPH						
Stack Effluent						
Flow rate - DSCFM (X1000)						
Flow rate - DSCF/ton						
Temperature - °F						
Water vapor - Vol. %	76.1	61.3	71.9	59.9	56.4	72.0
CO_2 - Vol. % dry	9.4	10.2	10.0	9.8	8.2	9.8
O_2 - Vol. % dry	13.2	11.0	12.2	12.0	13.1	11.8
CO - Vol. % dry	0.2	0.2	0.1	0.3	0.1	0.2
TRS Emissions						
ppm	1.7	0.8	0.5	0.4	0.3	0.5
lb/hr						
lb/ton of pulp						

Table 28 - TRS Emissions from Lime Kiln K

Summary of Results

Run Number	1	2	3	4	5	6
Date - 1974	4/5	4/5	4/9	4/9	4/10	4/10
Test Time - minutes	240	240	240	240	240	240
Production Rate - TPH	-	-	-	-	-	-
Stack Effluent						
Flow rate - DSCFM (X1000)	13.8	13.8	14.0	13.4	13.6	14.2
Flow rate - DSCF/ton	-	-	-	-	-	-
Temperature - °F	142	142	146	152	155	154
Water vapor - Vol. %	21.8	21.8	22.9	26.0	25.8	26.8
CO_2 - Vol. % dry	13.0	13.0	14.2	14.2	14.6	14.2
O_2 - Vol. % dry	7.6	7.6	7.1	7.1	6.4	7.2
CO - ppm	0	0	0	0	0	0
TRS Emissions						
ppm	4.6	12.0	4.5	4.8	4.0	5.2
lb/hr	0.34	0.88	0.33	0.34	0.29	0.39
lb/ton of pulp	-	-	-	-	-	-
SO_2 Emissions						
ppm	52	42	25	18	16	37
lb/hr	7.2	5.8	3.5	2.4	2.2	5.2
lb/ton of pulp	-	-	-	-	-	-

Table 29

ADDITIONAL TRS EMISSION DATA FOR LIME KILNS*

	Lime Kiln E TRS Concentration (ppm, daily average)			Lime Kiln O TRS Concentration (ppm, daily average)	
Month	Maximum	Average	Month	Maximum	Average
May 1973	1.4	0.3	Jan. 1973	14	6.8
June	3.4	0.7	Feb.	20	9.3
July	2.1	0.4	March	14	7.6
Aug.	1.4	0.3	April	32	9.6
Sept.	10.1	1.5	May	16	4.7
Oct.	7.1	1.0	June	10	3.4
Nov.	5.9	0.8	July	9	4.5
Dec.	8.9	1.0	Aug.	12	3.8
Jan. 1974	3.4	0.6	Sept.	17	5.0
Feb.	2.6	0.2	Oct.	34	8.2
March	0.7	0.1	Nov.	12	5.7
April	3.1	0.6	Dec.	22	9.8
May	2.9	0.7	Jan. 1974	30	17.9
			Feb.	33	21.1
			March	30	19.3
			April	40	16.2
			May	25	12.3
				Average = 9.7	

*Tested by operators using barton titrators.

APPENDIX D

EMISSION MEASUREMENT

Test methods for the measurement of particulate and TRS emissions from kraft pulp mills are specified as a means of determining compliance with the proposed standards. The sampling and analytical techniques associated with each method are discussed in this section.

EPA Standard Method 5 is used for the measurement of particulate emissions from the recovery furnace, the smelt dissolving tank, and the lime kiln. The provisions of this method were promulgated in the Federal Register on December 23, 1971 (36 FR 24877).

The reference test method for measurement of TRS emissions from kraft pulp mills is Method 16, "Semicontinuous Determination of Sulfur Emissions from Stationary Sources." The provisions of this method will be proposed in the Federal Register at the same time as the proposal of the new source performance standards for kraft pulp mills.

1. Particulate Sampling

Recognizing that there is probably no universal, absolutely accurate methods of particulate sampling, and that all available methods will likely give varying results for any single test, the reasoning for the selection of Method 5 as the test method to determine compliance with the proposed particulate standards for kraft recovery furnaces, lime kilns, and smelt dissolving tanks is presented below:

For particulate matter emissions in stacks, EPA relies primarily upon Method 5 for gathering the new source performance standard data base. Method 5 provides detailed sampling methodology; for example, the selection of the site at which to sample stacks or ducts is tightly controlled, along with the number of sample points and the method by which the sampling probe will traverse the area to be sampled. Method 5 equipment and procedures provide a means for realtime isokinetic sampling and for verification that isokinetic sampling was maintained within acceptable limits. Few other commonly accepted methods provide this level of detail, which is necessary to minimize subjectively, and to ensure reproducibility and representativeness of test results.

Since particulate matter is not an absolute quantity, but rather, is a function of temperature and pressure, it is necessary that particulate sampling methods take these parameters into account. Method 5, which includes an out-of-stack filter, provides a means for controlling temperature. Pressure within the sampling train exerts essentially no effect on indicated results. Although selection of temperature can be varied from industry to industry, a sampling temperature of 250° is used for most industrial sources. Reasons for selection of 250° include:

a. Filter temperatures must be held above 212°F at sources where moist gas streams are present. Below 212°F, condensation can occur and result in plugging of filters and possible gas/liquid reactions. A design temperature of 250° allows for expected temperature variation within the train, without dropping below 212°.

b. Systems of emission reduction capable of controlling matter which exists in particulate form at 250° can be employed on most industrial processes.

c. Adherence to one established temperature (even though some variation will be needed at some source categories) allows comparison from source category. This (limited) standardization is of benefit to equipment vendors and to source owners not subject to SPNSS because it provides a certain predictive capability, i.e., by sampling at 250°, results can be obtained which will in most cases be comparable to SPNSS development data. In-stack filtration, by comparison, takes place at stack temperature, which usually is not constant from one source to the next. Since the temperature varies, in-stack filtration does not necessarily provide a consistant definition of particulate matter.

Method 5 was used to obtain the data base for particulate emission standards for kraft mill recovery furnaces, lime kilns, and smelt dissolving tanks. Consequently, Method 5 is recommended for use as the reference compliance method.

Sampling problems. Since control devices of kraft recovery furnaces, lime kilns, and smelt dissolving tanks are generally followed by duct work and a stack, no special problems are anticipated.

Alternate Methods for Kraft Recovery Furnaces

Recognizing that in-stack filtration results in a simplification of compliance test procedures, EPA is not adverse to the idea of using such a method whenever:

a. The method produces the same results or have a known relationship to the method used for data gathering or the method subsequently established as the reference method.

b. The method measures pollutant emissions which are indicative of the performance of the best systems of emission reduction.

c. The method includes methodology conducive to producing consistent and reliable test results.

With respect to particulate matter, EPA has prepared an in-stack filter method. This method, which has been designated Method 17, is similar to Method 5 with the exception of the filter location and procedural differences associated with the filter location.

Data have been gathered showing the relationships of the in-stack method and Method 5. The first report is the one submitted by the National Council of the Paper Industry for Air and Stream Improvement (NCASI) in their Atmospheric Quality Improvement Technical Bulletin No. 67 (Oct. 1973) entitled "Comparison of Source Particulate Emission Measurement Methods at Kraft Recovery Furnace Stacks." The second test report is from EPA's own work. Both show that the average difference between the results of the two methods are relatively small, but the difference is real, by a value of 0.004 gr/dscf. Therefore, Method 17 is recommended for recovery furnaces as an alternate method for compliance purposes provided that a constant value of 0.004 gr/dscf is added to the results of Method 17 and the stack temperature is no greater than 400°F.

2. TRS Compliance Testing

The need for an effective test method for measurement of reduced sulfur emissions from stationary sources resulted from a standard of performance for new stationary source (SPNSS) program to establish performance standards for a variety of kraft mill unit processes with respect to malodorous emissions. As with previous SPNSS programs, test methodology was needed to gather (a) accurate data which would demonstrate emission limitations attainable through the use of best available emission control systems and (b) enough sampling and analytical data such that a reference method for performance testing could be prescribed.

At the inception of the SPNSS kraft mill program in January of 1972, a survey was made to evaluate existing test methods for potential use. This survey included a review of the literature, contact with mill personnel, and review of previous research and evaluation of analytical techniques by the Environmental Protection Agency(EPA). Since the degree to which methods are available for field use in odor measurements is directly related to the complexity of the odorant mixture to be measured, it was fortunate that the nature of emissions from kraft pulping operations had been well defined. Emissions consist primarily of sulfur dioxide (SO_2) and four reduced sulfur compounds--hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulfide (DMS), and dimethyl disulfide (DMDS). These compounds are highly reactive, particularly the H_2S-SO_2 mixture which form elemental sulfur, and are present in low concentrations in well controlled sources. In addition, the sources of these emissions (recovery furnaces, lime kilns, smelt dissolving tanks, digesters, multiple-effect evaporators, washer systems, oxidation systems, and concensate strippers) are characterized by high temperatures and moist, particulate-laden effluent streams.

After careful consideration, it was determined that an additive total reduced sulfur (TRS) standard, reflecting all sulfur compounds present minus SO_2, was desired. Considering this and the previously mentioned source conditions, a field method which could measure reduced sulfur compounds, either individually or collectively, was sought.

a. Methods Surveyed. A review of the literature revealed that analytical methods fell into four main categories: colorimetry, direct spectrophotometry, coulometry, and gas chromatography. Although most of the methods surveyed were developed for measurement of ambient concentrations, this did not preclude their possible application to the measurement of stack emissions.

(1) Colorimetry. A sample is bubbled through a solution which selectively absorbs the component or components desired. The absorbed compound is then reacted with specific reagents to form a characteristic color which is measured spectrophotometrically.

An example of a colorimetric method is the methylene blue method which involves the absorption of TRS compounds in an alkaline suspension of cadmium hydroxide to form a cadmium sulfide precipitate. The precipitate is then reacted with a strong acidic solution of N, N, dimethyl-P-phenylene-diamine and ferric chloride to give methylene blue, which is measured spectrophotometrically. Automated sampling and analytical trains using sequential techniques are available for this procedure. Inherent deficiencies for stack sampling applications include variable collection efficiency, range limitations, and interferences from oxidants.

Another colorimetric method is the use of paper tape samplers impregnated with either lead acetate or cadmium hydroxide. These compounds react specifically with H_2S and the resultant colored compound can be measured directly with a densitometer. Tape samplers would not be appropriate for all TRS compounds unless they were all reduced quantitatively to H_2S. In addition, the range is limited and the method suffers from light sensitivity, fading, the necessity for precise humidity control, and variability in tape response.

(2) Spectrophotometry. The use of infrared and mass spectrophotometry and other sophisticated spectroscopic methods for analysis of individual odorants is well established. However, these methods were considered expensive, time consuming, and not suitable for routine field applications.

One promising method in this area was split-beam ultraviolet spectrophotometry, which utilizes the strong absorption of ultraviolet radiation at 582 mm by SO_2. In this method the gas sample is mixed with air, filtered and split into two streams. One stream passes through a catalytic oxidation furnace where sulfur constituents are oxidized to SO_2 and then through an optical cell where its absorbance is measured. The second stream passes through a dummy furnace and then into a reference optical cell. The difference in absorbance values between the two cells is a measure of the non - SO_2 sulfur constituents in the sample stream. The system is capable of SO_2/TRS concentrations in the range of 10 to 2500 ppm. Since well-controlled kraft mill sources fall below the minimum range of 10 ppm, this method was considered not applicable.

(3) Coulometry. Coulometric titration is based on the principle of electrolytically generating a selected titrant in a titration cell. The titrant may be a free halogen (bromine or iodine) in aqueous solution as

an oxidizing agent, or a metal ion (silver), as a reducing agent. The electrolytic current required to generate the titrant, as it is consumed, is a linear measure of the concentration of reactive compounds in the gas sample.

The bromine coulometric titrator has been widely used by the kraft industry as a continuous process monitor for a number of years. Its distinct advantage over other coulometric devices is its ability to respond to a large variety of alkylsulfides, mercaptans, and thioethers, as well as H_2S and SO_2. However, the response to each compound is different, making standardization of the instrument and reporting of data difficult. For example, H_2S gives a response four times as high as the response of dimethyl sulfide for the same concentration. This problem was recognized by the paper industry and the coulometric titrator was modified to correct this problem. The modified procedure (Barton Titrator Model 400) utilizes a wet chemical scrubber (3% aqueous potassium acid phthalate) to remove SO_2 from the sample. The sample is then heated to convert the remaining TRS compounds to SO_2 which is measured by the coulometric titrator. Using this procedure, the instrument can be standardized with SO_2 and all data reported as TRS.

The literature, verbal communications with users of this method, and experience reveal several potential problem areas:

a. Deposition of elemental sulfur on the electrode, reducing sensitivity.

b. Maintenance problems with the SO_2 scrubber solution, resulting in variable collection efficiency.

c. Variations in response of pollutant concentrations and excessive zero drifts due to changes in sample flow rate.

d. Over-oxidation of TRS compounds to sulfur trioxide (SO_3), which is not detected by the coulometer.

(4) Gas Chromatography. This system is based on the ability of the gas chromatographic columns to separate individual sulfur compounds, which are then determined individually by various analytical techniques. The most sensitive determination is the flame photometric detector (FPD). This technique involves measurement of light emitted from the excited S_2 species formed when a sulfur compound is burned in a hydrogen-rich flame.

The GC/FPD system has several advantages. It can separate and detect the individual TRS compounds. The sensitivity of detection of each sulfur compound is less than 5 parts per billion-- a level below concentrations in well-controlled sources. By placing a narrow band-pass optical filter between the flame and a photomultiplier tube, a high specificity ratio (30,000:1) of sulfur to non-sulfur bearing constituents can be obtained, thereby eliminating most interferents. Other interfering components, carbon oxides and moisture, both can be selectively removed with a stripper column.

b. Methods Development.

(1) Analytical Techniques. Based on the survey, the GC/FPD technique was considered to be the most promising and was selected for field evaluation. At several of the plants, the coulometric titrator was also tried since this instrument was widely used by the industry at the time.

(2) Sample Collection. Considering the sulfur compound reactivity, high moisture, and presence of particulate matter, EPA developed a special sample handling system. It utilizes a sampling probe enclosed in a stainless steel sheath with inlet ports perpendicular to the stack wall. A deflector shield is fixed on the under side to deflect the heavier particles while

the probe is packed with glass wool to trap finer particles. Teflon tubing heated to 250°F is used to carry the sample from the probe to a dilution system where the sample is routinely diluted 1:9 with clean dry air. The heated sample line prevents condensation and teflon does not react with sulfur compounds. After the sample is diluted in a heated dilution box, its moisture content is reduced so that the dew point is below ambient temperature, preventing condensation and sample loss during analysis.

(3) Calibration of Instruments. For delivery to and calibration of analytical instruments, a special system containing permeation tubes with appropriate concentrations of SO_2, H_2S, DMS, DMDS, and CH_3SH were installed into the sampling and analytical system. These gas permeation tube standards were developed by EPA personnel specifically for use with GC systems.

(4) Field Evaluation. Since 1972, EPA has used the sample delivery system, dilution system, calibration system, and the GC/FPD methods at a number of kraft mills. Two separate GC/FPD systems were employed to facilitate the rapid analysis of both high and low molecular weight sulfur compounds. One system resolved H_2S, SO_2, CH_3SH, and DMS, while the other simultaneously resolved DMDS and other high molecular weight homologs. To ensure reliability of the data, the GC/FPD systems were frequently calibrated with standards of each of the sulfur compounds.

Field experience has shown that the GC/FPD method is most reliable, sensitive, and precise for determination of TRS. This has also been substantiated via verbal communications with industry experts.

Conversely, at six of these kraft mills, two different coulometric instruments have yielded poor results, possibly due to the low concentrations encountered, and the operational problems mentioned earlier. This instrument is unacceptable for compliance testing.

APPENDIX E

MILL CHARACTERISTICS

APPENDIX E
MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
ALABAMA					
Allied Paper, Inc. (Subsidiary of SCM)	490	Jackson	Recent, current	1,2	Printing & Writing Papers
American Can Company	900	Butler	None	1,2,4	Tissue; toweling; box, paper, & pkg board
Champion International	500	Courtland	Planned	None	Uncoated Printing, Writing, Business & Converting Papers
Container Corporation of America (Sub. of MARCOR)	850	Brewton	None	None	Paperboard; Food-liquid board; Kraft paper; linerboard
Georgia Kraft Corp. (50% owned by Inland Container; 50% owned by Mead Corp.)	975	Mahrt	None	None	Linerboard; kraft board
Gulf States Paper Corp.	400	Demopolis	Planned	None	Paperboard
Gulf States Paper Corp.	475	Tuscaloosa	None	None	Kraft Bag & Wrapping
Hammermill Paper Co.	500	Selma	None	1,2	None

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*Derived from: Post's 1973, 1974, 1975, 1976 Pulp and Paper Directory; Pulp and Paper magazine June 30, 1975, Vol. 49, No. 7; and Control of Atmospheric Emissions in the Wood Pulping Industry, Vol. 1, a report to the National Air Pollution Control Administration, 1970; and discussions with industry.

**Recent: took place in 1974; Current: took place in 1975; Planned: will take place from 1976 and later. Note these capacity additions may be at operations ancillary to the pulp mill.

***1. bleached kraft hardwood pulp; 2. bleached kraft softwood pulp; 3. unbleached kraft pulp; 4. semi-bleached pulp.

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		ALABAMA (Con't)			
International Paper Co.	1,350	Mobile	None	None	Paper
Kimberly-Clark Corp.	585	Coosa Pines	Planned	1,2,3	Newsprint
MacMillan Bloedel Ltd.	925	Pine Hill	None	None	Paperboard
Scott Paper Co.	1,400	Mobile	None	None	Tissue & Other Paper Grades
Union Camp Corp.	930	Montgomery	Planned	None	Paperboard
		ARIZONA			
Southwest Forest Industries	600	Snowflake	Current	None	Newsprint, Linerboard
		ARKANSAS			
Georgia-Pacific Corp.	1,500	Crossett	Recent	1,2,3,4	Kraft Paper, Tissue, & Paperboard
Great Northern Nekoosa Corp.	400	Ashdown	Recent & Current	1,2	Business Communications Papers
Green Bay Packaging, Inc.	650	Morrilton	Recent	3	Paperboard
International Paper Co.	750	Camden	None	None	Paper
International Paper Co.	1,900	Pine Bluff	Recent	None	Paper & Board
Weyerhauser Company	230	Pine Bluff	None	None	Paper & Board

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		CALIFORNIA			
Crown Simpson Co. (jointly owned by Crown Zellerbach & Simpson Lee Paper Co.)	600	Fairhaven	None	1,4	None
Fibreboard Corp.	450	Antioch	None	None	Paperboard
Louisiana-Pacific Corp.	700	Samoa	None	2	None
Simpson Lee Paper Co.	160	Anderson	Current, Planned	None	Coated Printing Paper, Machine Finish Grades
		FLORIDA			
Alton Box Board Co.	650	Jacksonville	Current	None	Board
Container Corp. of America (Sub. of MARCOR)	1,400	Fernandina Beach	None	None	Paperboard
Hudson Pulp & Paper Corp.	950	Palatka	Planned	1,2,3	Tissue and Bag Papers
International Paper Co.	1,500	Panama City	None	1,2	Containerboard
Procter & Gamble Co.	900	Foley	None	2	None
St. Joe Paper Co.	1,300	Port St. Joe	None	None	Paperboard
St. Regis Paper Co.	1,510	Jacksonville	Current	None	Kraft Paper & Board
St. Regis Paper Co.	1,050	Pensacola	None	None	Paper & Board

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		GEORGIA			
Continental Can Co.	800	Augusta	Recent	None	Paperboard
Continental Can Co.	600	Port Wentworth	Current	None	Paperboard
Brunswick Pulp & Paper Co. (50% owned by Mead Corp.; 50% owned by Scott Paper)	1,550	Brunswick	Recent	1,2	Paperboard
Georgia Kraft Corp. (50% owned by Inland Container Corp.; 50% owned by Mead Corp.)	1,550	Krannert (Rome)	None	None	Paperboard (Containerboard)
Georgia Kraft Corp. (same as above)	900	Macon	Planned	None	Paperboard (Containerboard)
Gilman Paper Co.	1,100	St. Marys	Recent	None	Paper & Board
Great Northern Nekoosa Corp.	1,780	Cedar Springs	Current	None	Paperboard & Corrugating Medium
Interstate Paper Corp.	550	Riceboro	None	None	Paperboard & Kraft Board
ITT Rayonier, Inc.	1,250	Jesup	Recent	1,2	None
Owens-Illinois, Inc.	875	Valdosta	None	3	Board
Union Camp Corp.	2,550	Savannah	Recent, Current & Planned	None	Paperboard, Unbleached Paper, & Semichemical Medium

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		IDAHO			
Potlatch Corp.	950	Lewiston	Recent, Planned	2	Paperboard & Tissue
		KENTUCKY			
Western Kraft (Div. of Willamette Industries, Inc.)	320	Hawesville	None	1	None
Westvaco	600	Wickliffe	None	1	Fine Papers
		LOUISIANA			
Boise Cascade Corp.	1,250	DeRidder	None	None	Newsprint & Linerboard
Boise Cascade Corp.	325	Elizabeth	None	None	Bag, Bag Lining, Convertin, Envelopes, Wrapping
Continental Can Co.	1,400	Hodge	Current & Planned	None	Coarse Paper & Paperboard
Crown Zellerbach	1,350	Bogalusa	None	None	Paperboard, Kraft Wrapping & Bag
Crown Zellerbach	500	St. Francisville	None	None	Coated Papers, Kraft Paper & Board
Georgia-Pacific Corp.	1,600	Port Hudson	Planned	1,2,3,4	None
International Paper Co.	1,100	Bastrop	None	None	Kraft Paper & Board
International Paper Co.	1,650	Springhill	None	1,2	Paper & Board
Western Kraft	450	Campti	Recent, Current & Planned	1,2	Paper & Board

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		LOUISIANA (CONT.)			
Olin Kraft, Inc.	1,150	West Monroe	Recent & Planned	None	Kraft Paper and Board, & Corrigating Medium
Pineville Kraft Corp.	880	Pineville	Recent, Current & Planned	None	Kraft Liner Board
		MAINE			
Diamond International Corp.	425	Old Town	Current & Planned	1	Tissue
Georgia-Pacific Corp.	1,170	Woodland	Recent	1,2,3,4	Printing Papers & Newsprint
International Paper Co.	1,150	Jay (Androscoggin)	Planned	None	Bond, Carbonizing, & Coated Printing Papers
Lincoln Pulp & Paper Co., Inc. Div. of Premoid	320	Lincoln	Recent	None	Fine Paper & Tissue
Oxford Paper (Div. of Ethyl Corp.)	585	Rumford	Recent, Current, & Planned	1	Fine, Printing & Publishing Papers
S. D. Warren Co. Div. of Scott Paper Co.	300	Westbrook	None	None	Specialty & Other Papers
		MARYLAND			
Westvaco Corp.	665	Luke	None	None	Fine Papers
		MICHIGAN			
Mead Corp.	600	Escanaba	None	1,2	Coated Printing Papers
Scott Paper Co.	225	Muskegon	None	1,2,3,4	Fine Papers
		MINNESOTA			
Boise Cascade Corp.	465	Int'l Falls	None	None	Printing, Publishing, & White Papers; Insulation Board

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		MINNESOTA (CONT.)			
Potlatch Corp.	400	Cloquet	Recent, current, planned	None	Printing & Business Paper
		MISSISSIPPI			
International Paper Co.	715	Moss Point	None	None	Paper
International Paper Co.	1,000	Natchez	None	1,2	None
International Paper Co.	1,200	Vicksburg	None	None	Containerboard
St. Regis Paper Co.	1,792	Monticello	Current	None	Linerboard & Paper
		MONTANA			
Hoerner Waldorf Corp.	1,200	Missoula	Planned	2,4	Paperboard
		NEW HAMPSHIRE			
Brown Co.	700	Berlin-Gorham	Current	1,3	Paper, Printing, Industrial Tissue and Towel, Corrugating
		NEW YORK			
International Paper Co.	590	Ticonderoga	None	None	Book & Business Grades
		NORTH CAROLINA			
Champion International	1,360	Canton	Recent	None	Uncoated Printing, Writing, & Converting Papers; Bleached Paperboard for Milk & Folding Cartons

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		NORTH CAROLINA (CONT.)			
Federal Paper Board Co.	1,200	Riegelwood	Recent & Current	1,2	Paperboard
Hoerner Waldorf Corp.	950	Roanoke Rapids	Recent	None	Paperboard
Weyerhaeuser Co.	640	New Bern	None	1,2,4	None
Weyerhaeuser Co.	1,500	Plymouth	Current, Planned	None	Paperboard & Fine Papers
		OHIO			
Mead Corp.	540	Chillocothe	Recent & Planned	None	Fine Papers
		OKLAHOMA			
Weyerhaeuser Co	1,600	Valliant	None	None	Paperboard
		OREGON			
American Can Co.	340	Halsey	None	1,2,4	Tissue
Boise Cascade Corp.	1,050	St. Helens	Current	None	Specialty & Fine Papers
Crown Zellerbach	916	Clatskanie	None	None	Newsprint, Tissue, Industrial

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		OREGON (CONT.)			
Georgia-Pacific	1,250	Toledo	Current	None	Kraft Paper, Paperboard
International Paper Co.	600	Gardiner	None	None	Paperboard
Western Kraft (Willamette Industries, Inc.)	600	Albany	None	None	Kraft Papers, Corrugating Medium
Weyerhaeuser Co.	1,150	Springfield	Planned	None	Paperboard
		PENNSYLVANIA			
Appleton Papers, Inc. (Div. of National Cash Register)	180	Roaring Springs	None	None	Fine Papers
P. H. Glatfelter Co.	500	Spring Grove	Current, Planned	None	Printing & Writing Papers
Penntech Papers, Inc.	180	Johnsonburg	None	None	Fine, Printing, Publishing, & Business Paper
		SOUTH CAROLINA			
Bowater, Inc.	1,000	Catawba	Recent	1,2,4	Book Papers
International Paper Co.	1,830	Georgetown	Current & Planned	None	Board & Corrugating Medium
South Carolina Ind., Inc. (79% Owned by Stone Cont. Corp.)	675	Florence	Current	None	Paperboard
Westvaco Corp.	1,989	Charleston	Recent	None	Paperboard
		TENNESSEE			
Bowater, Inc.	500	Calhoun	None	4	Newsprint
Packaging Corp. of America (Sub. of Tenneco)	775	Counce	Current	None	Paperboard

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		TEXAS (CONT.)			
Champion International	820	Pasedena	Planned	None	Uncoated & Coated Printing Writing & Converting Papers
International Paper Co.	650	Texarkana	Planned	1,2	Paperboard
Owens-Illinois, Inc.	900	Orange	Planned	3	Board
Southland Paper Mills, Inc.	500	Houston	Recent	3,4	Newsprint & Kraft Paper
Southland Paper Mills, Inc.	400	Lufkin	Recent & Planned	3,4	Newsprint
Temple-Eastex, Inc. (Sub. of Time, Inc.)	1,300	Evadale	Planned	None	Paper & Paperboard
		VIRGINIA			
Chesapeake Corp. of Vir.	1,150	West Point	Recent, Current	1,2,3	Coarse Paper & Paperboard
Continental Can Co.	900	Hopewell	None	None	Paperboard
Union Camp Corp.	1,500	Franklin	Current	None	Paperboard & Fine, Industrial and Coarse Papers
Westvaco Corp.	1,000	Covington	None	None	Paperboard & Corrugating Medium
		WASHINGTON			
Boise Cascade Corp.	700	Wallula	Current	None	Linerboard & Corrugating Medium
Crown Zellerbach	730	Camas	None	None	Tissues, Industrial, & Fine Papers

MILL CHARACTERISTICS*

Owners	Size (Ton/Day)	Location	Capacity Additions**	Market Pulp Grades***	Paper & Paperboard Produced at this Location
		WASHINGTON (Con't)			
Crown Zellerbach	420	Port Townsend	Current, Recent	None	Paper & Paperboard
Longview Fibre Co.	1,900	Longview	Current & Planned	None	Paperboard & Kraft Paper
St. Regis Paper Co.	1,029	Tacoma	None	2,3,4	Linerboard, Natural & White Paper
Weyerhaeuser Co.	375	Everett	Current	1,2,4	None
Weyerhaeuser Co.	700	Longview	Current	1,2,4	Paperboard & Bristol Papers
		WISCONSIN			
Consolidated Papers, Inc.	395	Wisconsin Rapids	Recent & Planned	None	None
Great Northern Nekoosa Corp.	330	Nekoosa	Recent	None	Business Communications Papers
Hammermill Paper Co.	356	Kaukauna	Recent & Planned	None	Packaging & Special Industrial Papers
Mosinee Paper Corp.	175	Mosinee	Planned	None	Paper & Paperboard

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES Volume 1 discusses the PROPOSED STANDARDS and the resulting environmental and economic effects. Volume 2, to be published when the Standards are promulgated, will contain public comments on the Proposed Standards, EPA responses, and a discussion of differences between the Proposed and Promulgated Standards.

16. ABSTRACT

Standards of performance for the control of emissions of total reduced sulfur (TRS) and particulate matter from new and modified kraft pulp mills are being proposed under the authority of section 111 of the Clean Air Act. TRS emissions from kraft pulp mills are extremely odorous, and there are numerous instances of poorly controlled mills creating public odor problems. The proposed standards would prevent odor problems from most newly constructed kraft pulp mills, except in the immediate vicinity of the mills on occasions when meteorological conditions produce downwash of stack plumes. Particulate matter emissions from new mills would be reduced by more than 99 percent below the levels that would result from no control and more than 50 percent below the average levels that are being achieved by existing facilities controlled to the average State standards. Emissions of TRS would be reduced by more than 95 percent below the uncontrolled levels and more than 80 percent below the average levels for existing sources. An analysis of the environmental and economic effects associated with the proposed standards is included in this document.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution Pollution control Standards of performance Kraft pulp mills Total reduced sulfur Particulate matter	Air pollution control	

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